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Yoshihashi et al.

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(54) **REDUNDANT SYSTEM, REDUNDANCY METHOD, AND COMPUTER-READABLE RECORDING MEDIUM**

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G06F 11/20 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 11/2028*** (2013.01); ***G06F 11/2041*** (2013.01); ***G06F 11/2048*** (2013.01); ***G06F 11/2097*** (2013.01); *G06F 2201/80* (2013.01); *G06F 2201/82* (2013.01); *G06F 2201/84* (2013.01)

(58) **Field of Classification Search**
CPC G06F 11/2056; G06F 11/2058; G06F 11/2094; G06F 11/2082
See application file for complete search history.

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(57) **ABSTRACT**

A primary system includes a first node and a second node that backs up the first node. A secondary system includes a third node and a fourth node that backs up the third node. The first node transmits data update information generated in response to a data update in the first node, to the second node and the third node. The fourth node determines a degree of progress in transactions indicated by data update information obtained through the second node and a degree of progress in transactions indicated by data update information obtained through the third node, identifies data update information indicating a further progressed transaction, and reflects the data update information in stored data of the fourth node.

5 Claims, 17 Drawing Sheets

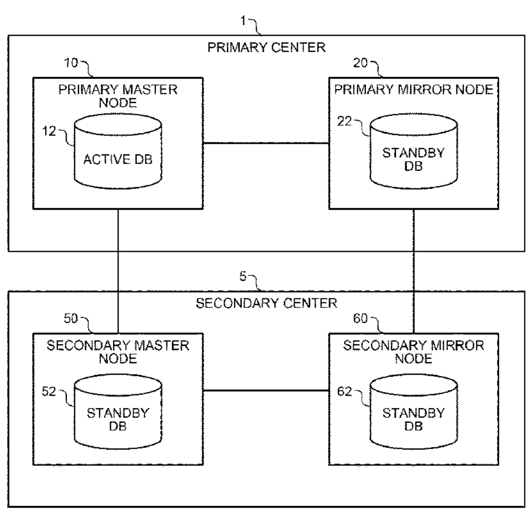

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FIG.1

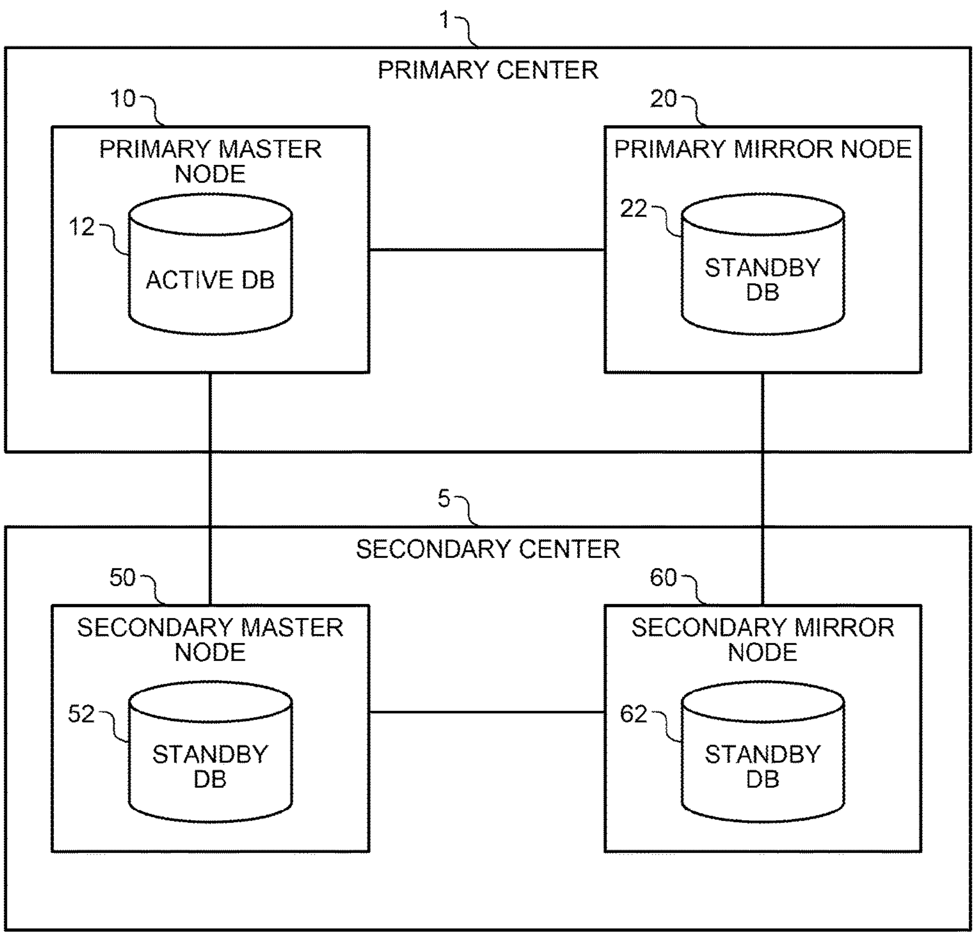

1
PRIMARY CENTER
10
PRIMARY MASTER NODE
12
ACTIVE DB
20
PRIMARY MIRROR NODE
22
STANDBY DB
5
SECONDARY CENTER
50
SECONDARY MASTER NODE
52
STANDBY DB
60
SECONDARY MIRROR NODE
62
STANDBY DB

FIG.2

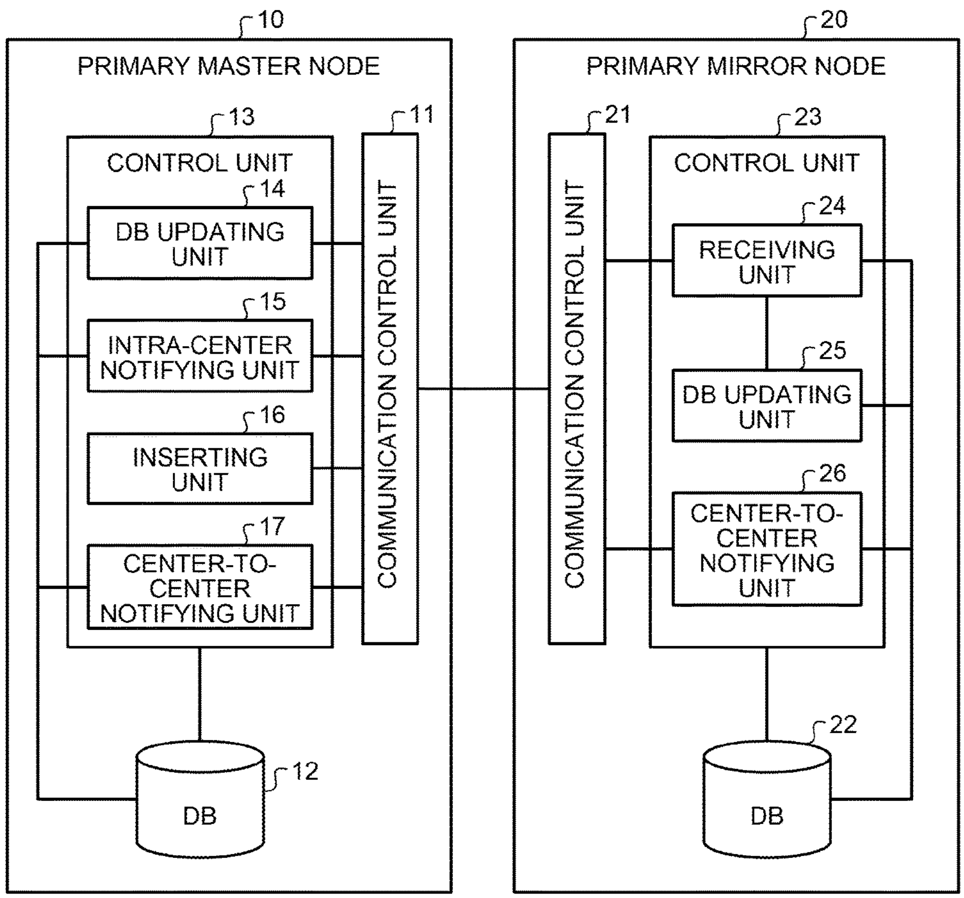

10
PRIMARY MASTER NODE
13
CONTROL UNIT
14
DB UPDATING UNIT
15
INTRA-CENTER NOTIFYING UNIT
16
INSERTING UNIT
17
CENTER-TO-CENTER NOTIFYING UNIT
11
COMMUNICATION CONTROL UNIT
12
DB
20
PRIMARY MIRROR NODE
21
COMMUNICATION CONTROL UNIT
23
CONTROL UNIT
24
RECEIVING UNIT
25
DB UPDATING UNIT
26
CENTER-TO-CENTER NOTIFYING UNIT
22
DB

FIG.3

FIG.4

FIG.5

FIG.6

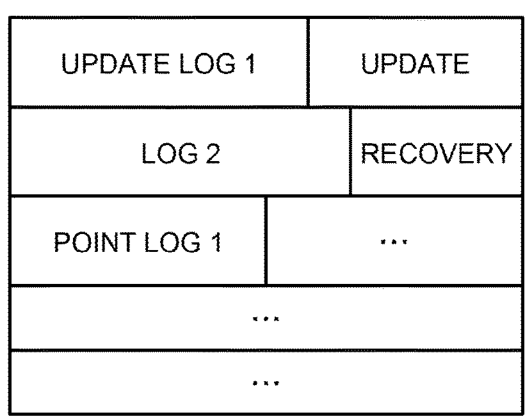


FIG.7

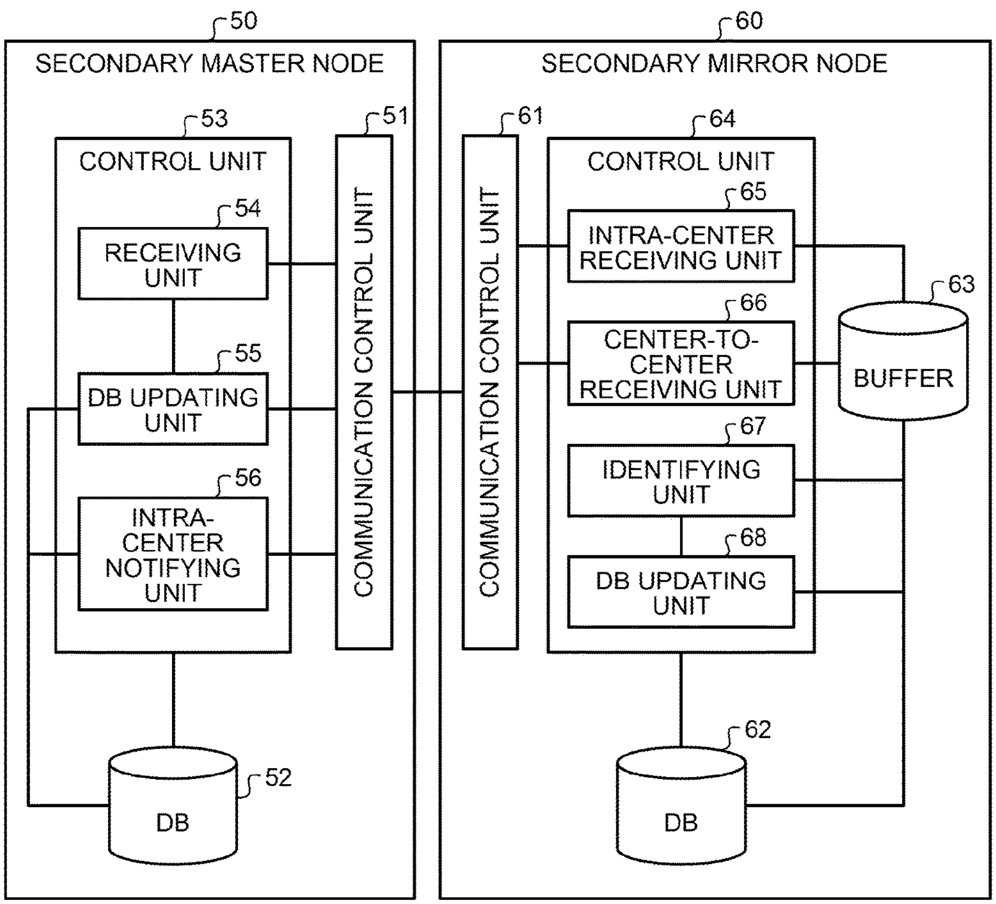

50
SECONDARY MASTER NODE
53
CONTROL UNIT
54
RECEIVING UNIT
55
DB UPDATING UNIT
56
INTRA-CENTER NOTIFYING UNIT
51
COMMUNICATION CONTROL UNIT
52
DB
60
SECONDARY MIRROR NODE
61
COMMUNICATION CONTROL UNIT
64
CONTROL UNIT
65
INTRA-CENTER RECEIVING UNIT
66
CENTER-TO-CENTER RECEIVING UNIT
67
IDENTIFYING UNIT
68
DB UPDATING UNIT
63
BUFFER
62
DB

FIG.8

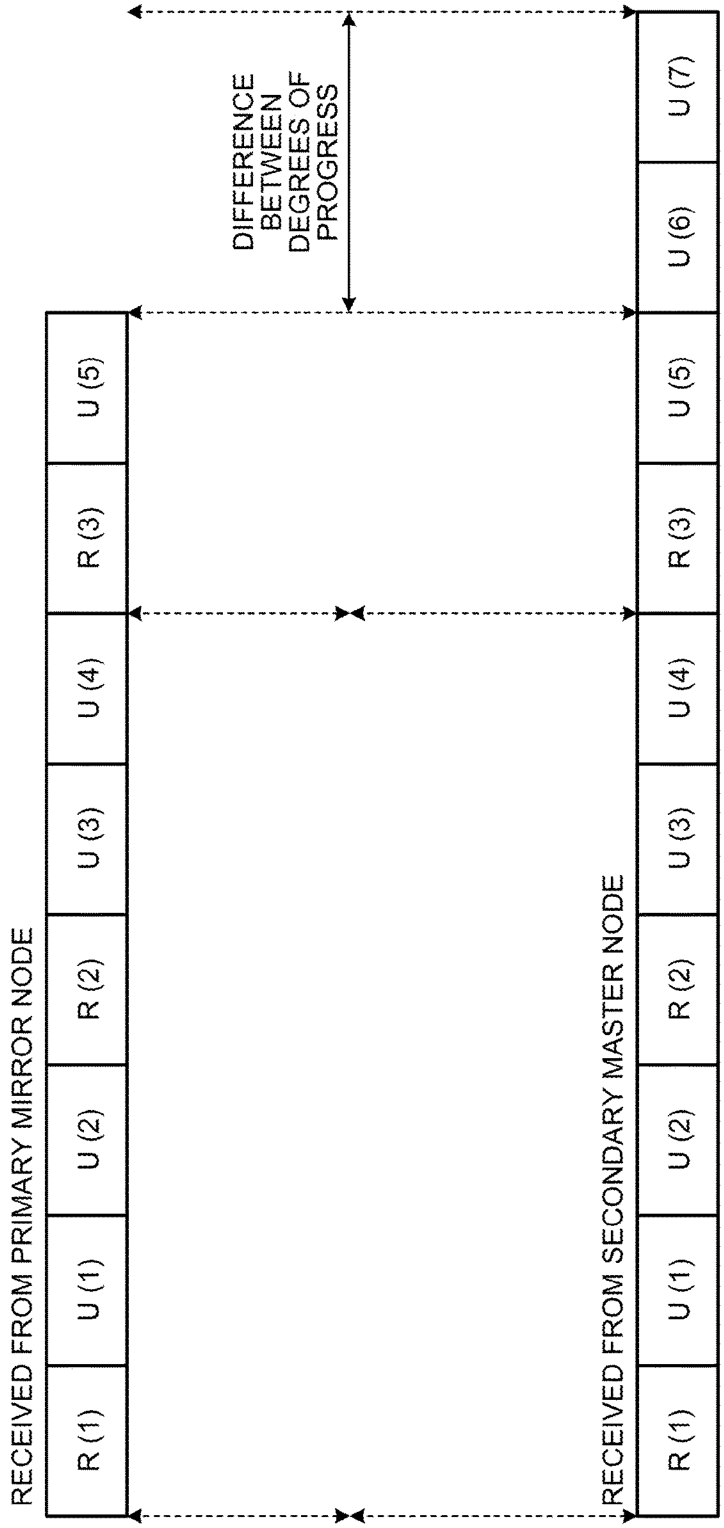

RECEIVED FROM PRIMARY MIRROR NODE
R (1)
U (1)
U (2)
R (2)
U (3)
U (4)
R (3)
U (5)
RECEIVED FROM SECONDARY MASTER NODE
R (1)
U (1)
U (2)
R (2)
U (3)
U (4)
R (3)
U (5)
U (6)
U (7)
DIFFERENCE BETWEEN DEGREES OF PROGRESS

FIG.9

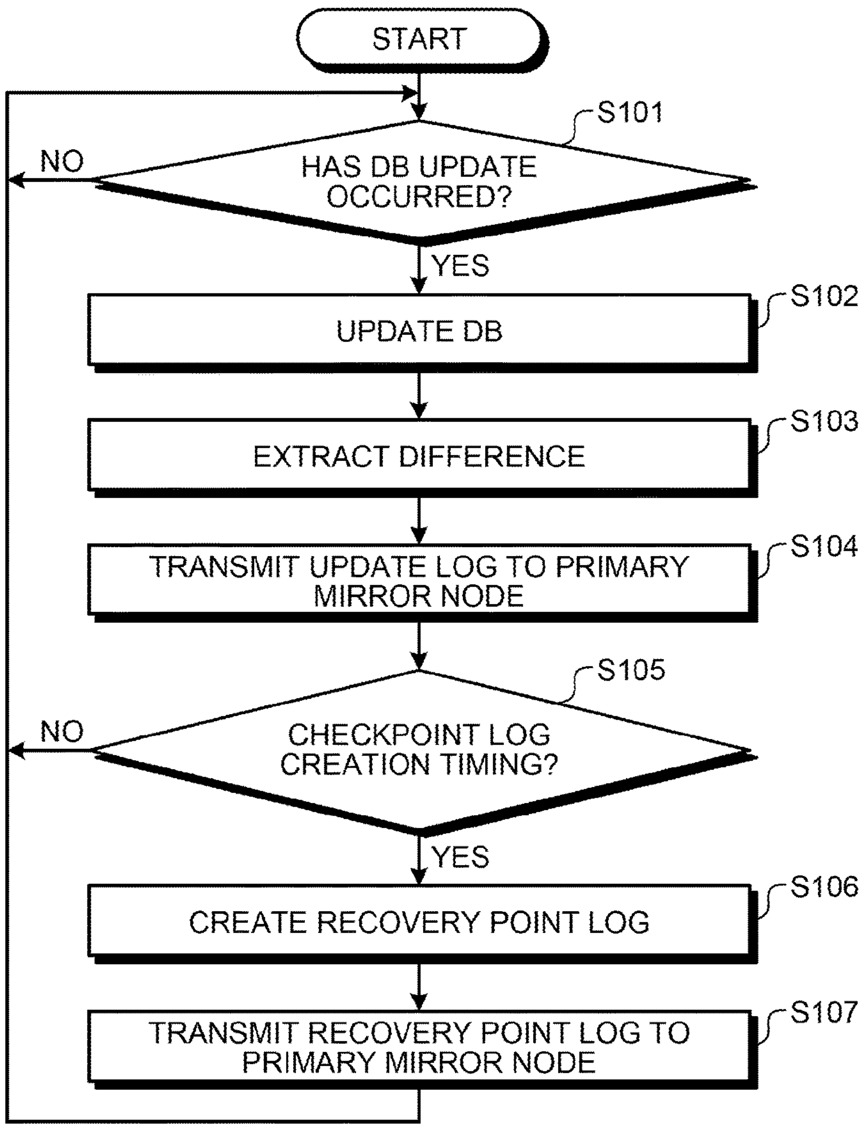

START
S101
HAS DB UPDATE OCCURRED?
NO
YES
S102
UPDATE DB
S103
EXTRACT DIFFERENCE
S104
TRANSMIT UPDATE LOG TO PRIMARY MIRROR NODE
S105
CHECKPOINT LOG CREATION TIMING?
NO
YES
S106
CREATE RECOVERY POINT LOG
S107
TRANSMIT RECOVERY POINT LOG TO PRIMARY MIRROR NODE

FIG.10

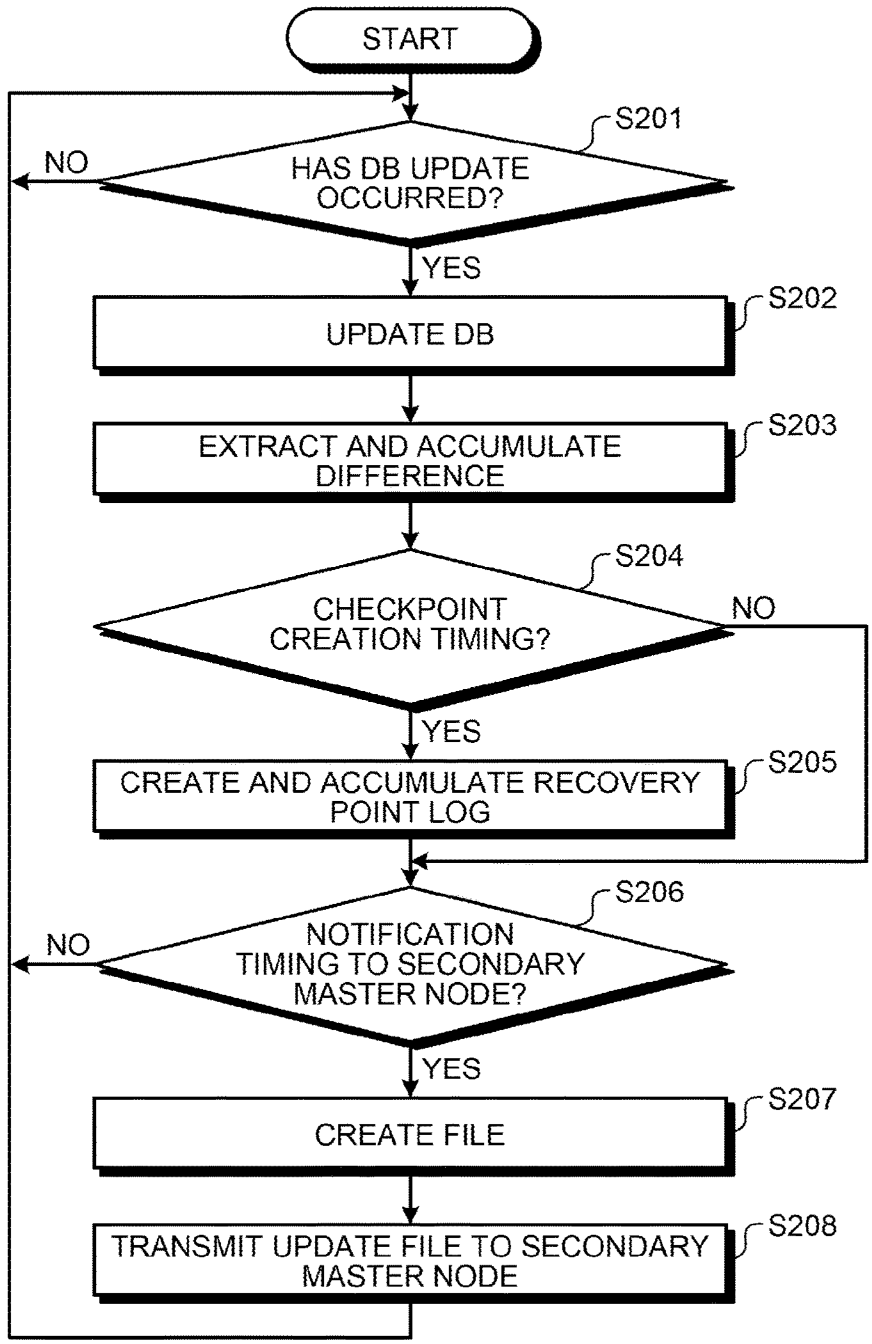

START
S201
HAS DB UPDATE OCCURRED?
NO
YES
S202
UPDATE DB
S203
EXTRACT AND ACCUMULATE DIFFERENCE
S204
CHECKPOINT CREATION TIMING?
NO
YES
S205
CREATE AND ACCUMULATE RECOVERY POINT LOG
S206
NOTIFICATION TIMING TO SECONDARY MASTER NODE?
NO
YES
S207
CREATE FILE
S208
TRANSMIT UPDATE FILE TO SECONDARY MASTER NODE

FIG.11

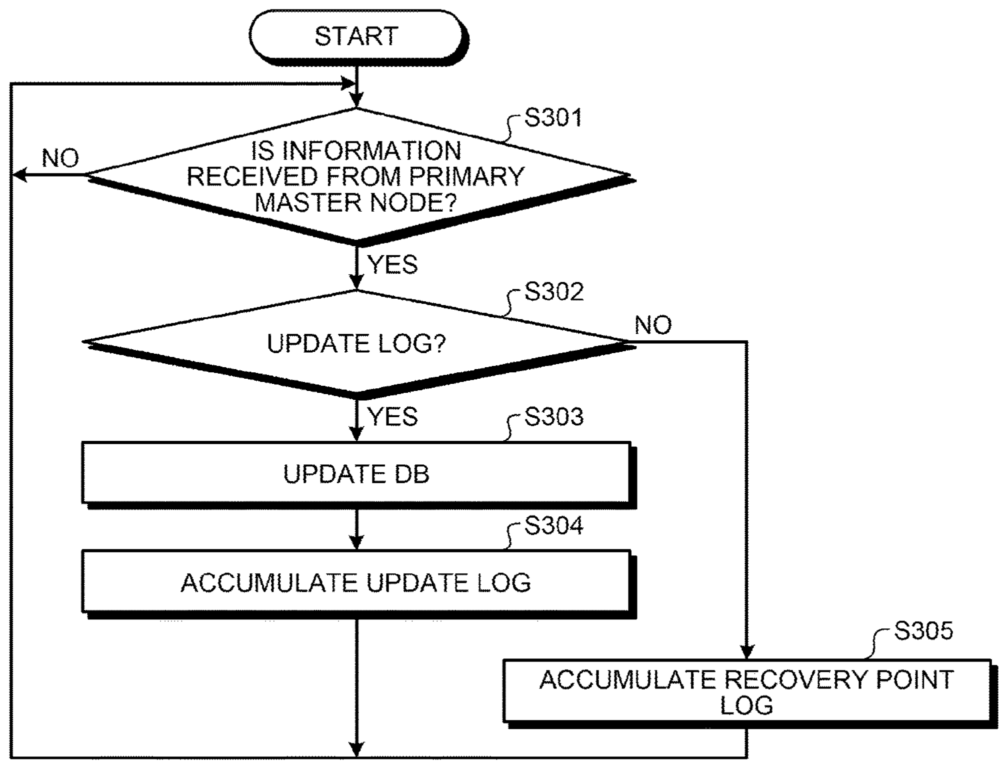

START
S301
IS INFORMATION RECEIVED FROM PRIMARY MASTER NODE?
NO
YES
S302
UPDATE LOG?
NO
YES
S303
UPDATE DB
S304
ACCUMULATE UPDATE LOG
S305
ACCUMULATE RECOVERY POINT LOG

FIG.12

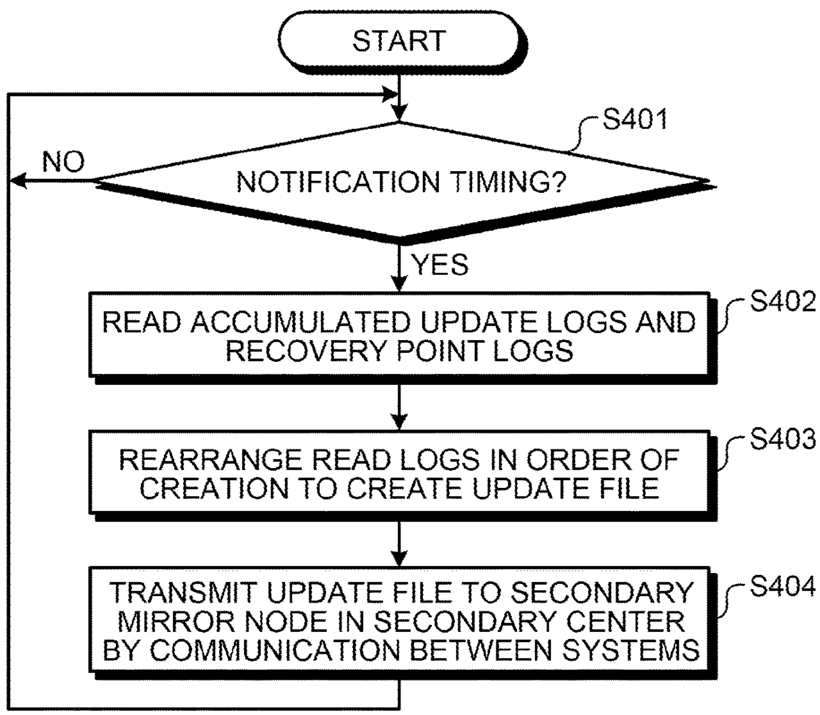

START
S401
NOTIFICATION TIMING?
NO
YES
READ ACCUMULATED UPDATE LOGS AND RECOVERY POINT LOGS
S402
REARRANGE READ LOGS IN ORDER OF CREATION TO CREATE UPDATE FILE
S403
TRANSMIT UPDATE FILE TO SECONDARY MIRROR NODE IN SECONDARY CENTER BY COMMUNICATION BETWEEN SYSTEMS
S404

FIG.13

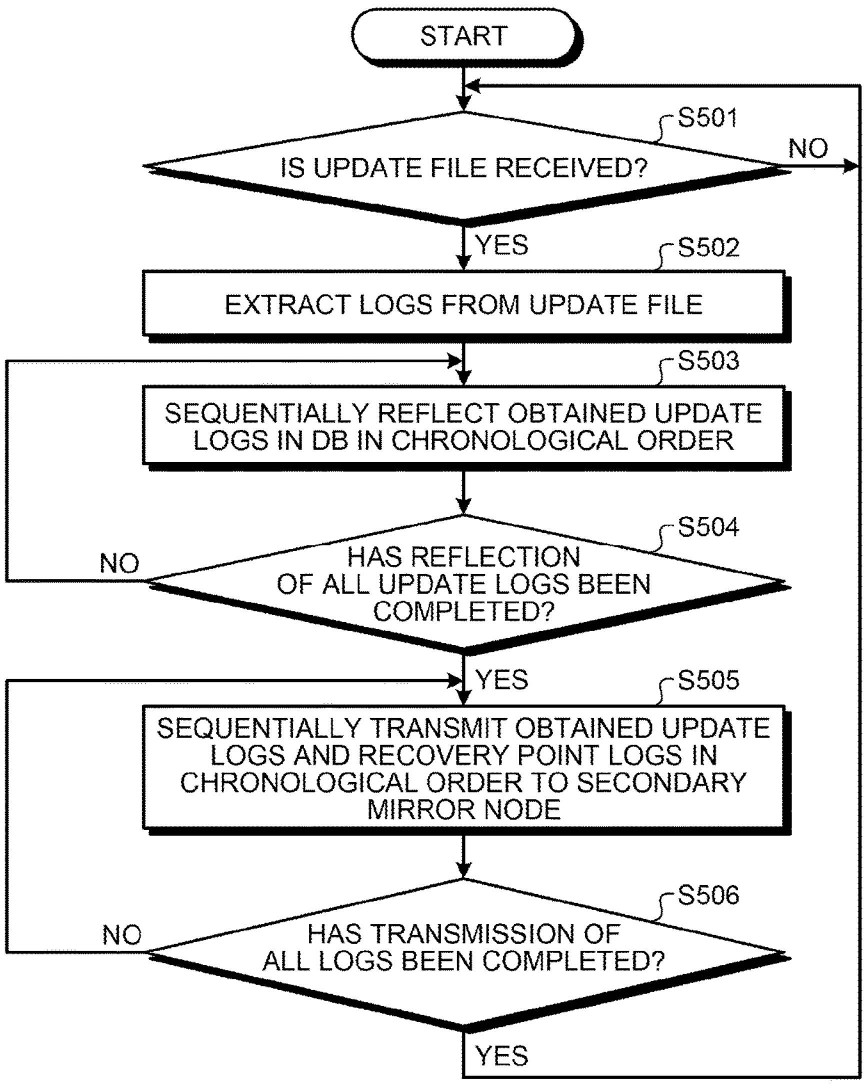

START
S501
IS UPDATE FILE RECEIVED?
NO
YES
S502
EXTRACT LOGS FROM UPDATE FILE
S503
SEQUENTIALLY REFLECT OBTAINED UPDATE LOGS IN DB IN CHRONOLOGICAL ORDER
S504
HAS REFLECTION OF ALL UPDATE LOGS BEEN COMPLETED?
NO
YES
S505
SEQUENTIALLY TRANSMIT OBTAINED UPDATE LOGS AND RECOVERY POINT LOGS IN CHRONOLOGICAL ORDER TO SECONDARY MIRROR NODE
S506
HAS TRANSMISSION OF ALL LOGS BEEN COMPLETED?
NO
YES

FIG.14

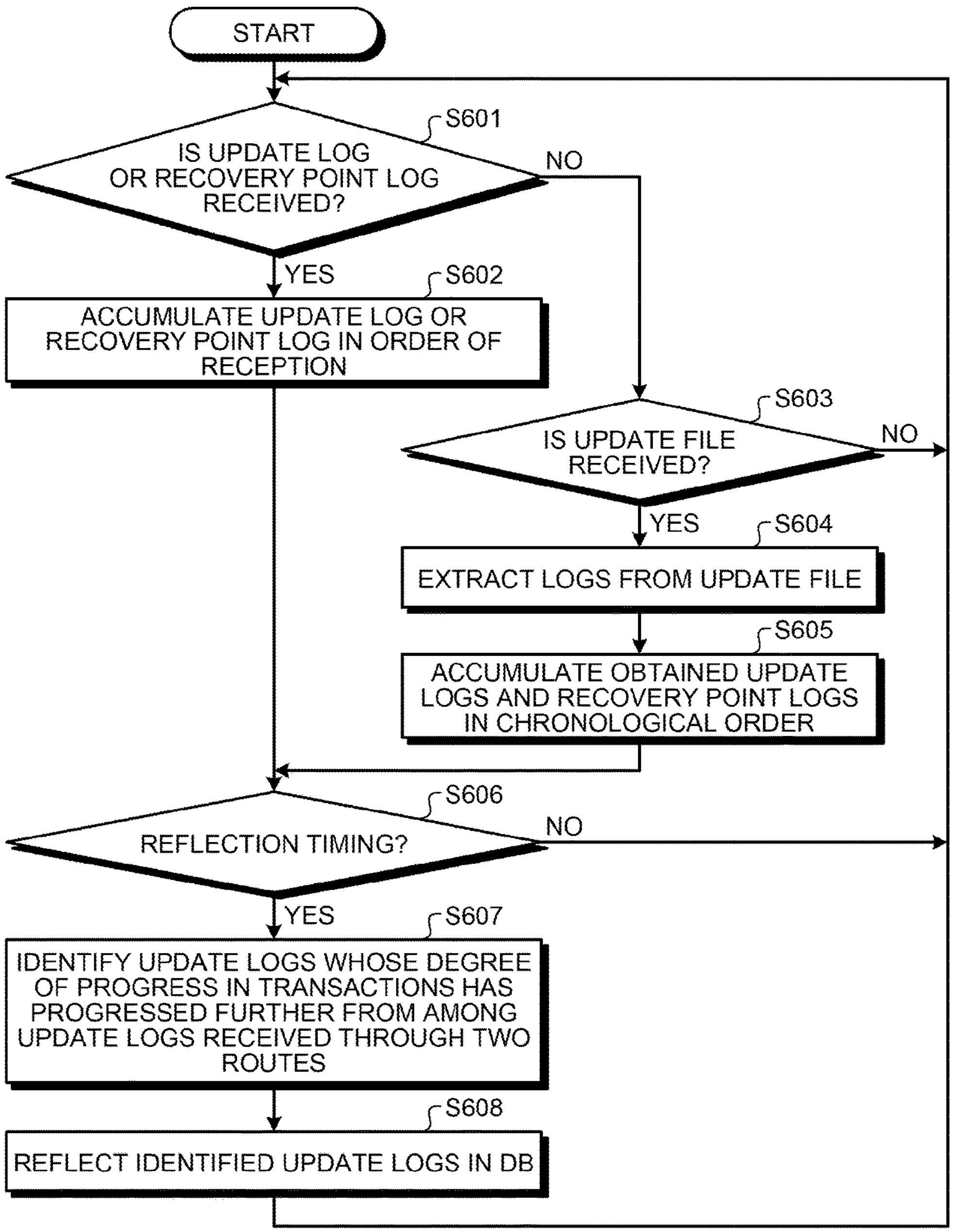

START
S601
IS UPDATE LOG OR RECOVERY POINT LOG RECEIVED?
NO
YES
S602
ACCUMULATE UPDATE LOG OR RECOVERY POINT LOG IN ORDER OF RECEPTION
S603
IS UPDATE FILE RECEIVED?
NO
YES
S604
EXTRACT LOGS FROM UPDATE FILE
S605
ACCUMULATE OBTAINED UPDATE LOGS AND RECOVERY POINT LOGS IN CHRONOLOGICAL ORDER
S606
REFLECTION TIMING?
NO
YES
S607
IDENTIFY UPDATE LOGS WHOSE DEGREE OF PROGRESS IN TRANSACTIONS HAS PROGRESSED FURTHER FROM AMONG UPDATE LOGS RECEIVED THROUGH TWO ROUTES
S608
REFLECT IDENTIFIED UPDATE LOGS IN DB

FIG.15

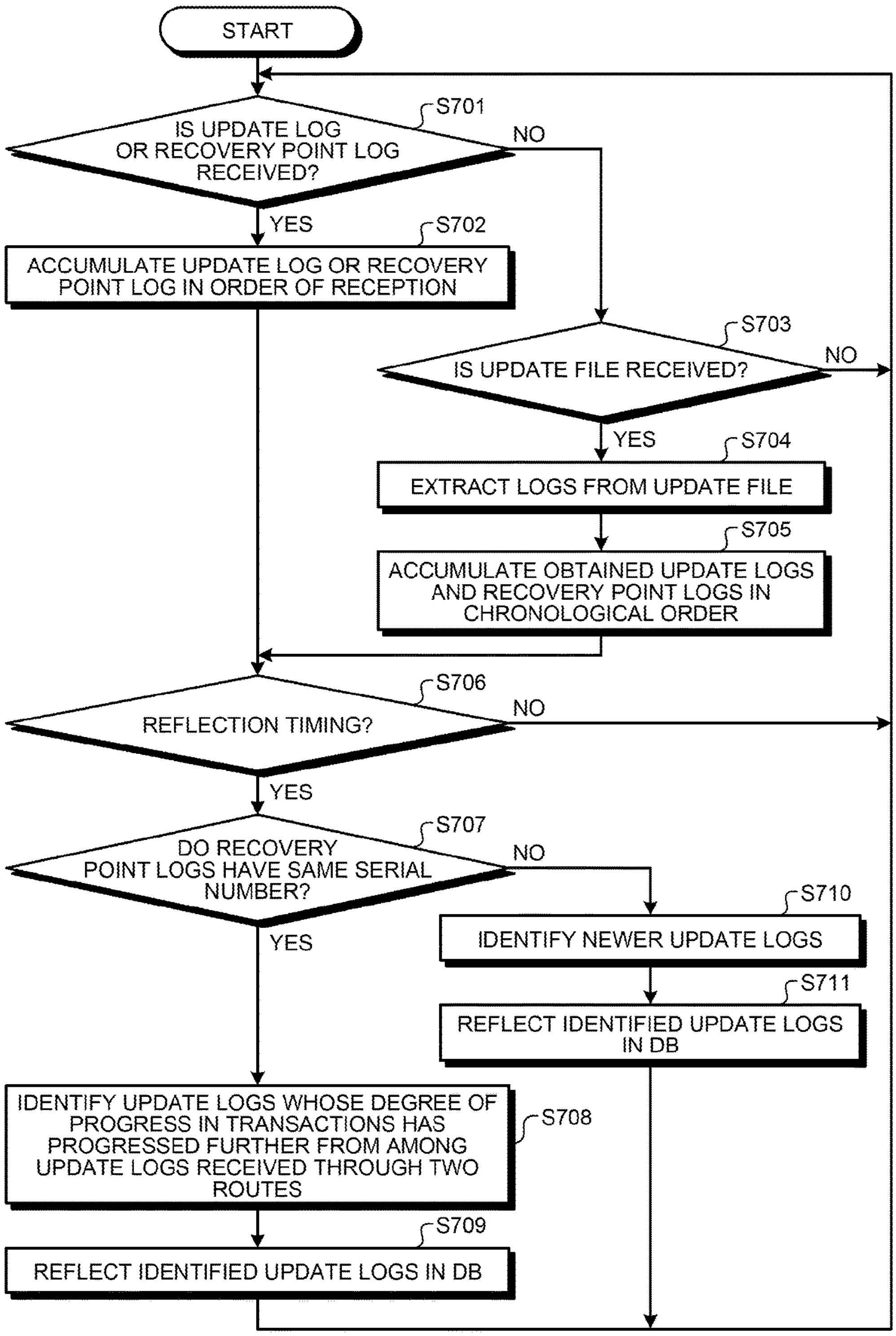

START
S701
IS UPDATE LOG OR RECOVERY POINT LOG RECEIVED?
NO
YES
S702
ACCUMULATE UPDATE LOG OR RECOVERY POINT LOG IN ORDER OF RECEPTION
S703
IS UPDATE FILE RECEIVED?
NO
YES
S704
EXTRACT LOGS FROM UPDATE FILE
S705
ACCUMULATE OBTAINED UPDATE LOGS AND RECOVERY POINT LOGS IN CHRONOLOGICAL ORDER
S706
REFLECTION TIMING?
NO
YES
S707
DO RECOVERY POINT LOGS HAVE SAME SERIAL NUMBER?
NO
YES
S710
IDENTIFY NEWER UPDATE LOGS
S711
REFLECT IDENTIFIED UPDATE LOGS IN DB
IDENTIFY UPDATE LOGS WHOSE DEGREE OF PROGRESS IN TRANSACTIONS HAS PROGRESSED FURTHER FROM AMONG UPDATE LOGS RECEIVED THROUGH TWO ROUTES
S708
S709
REFLECT IDENTIFIED UPDATE LOGS IN DB

FIG.16

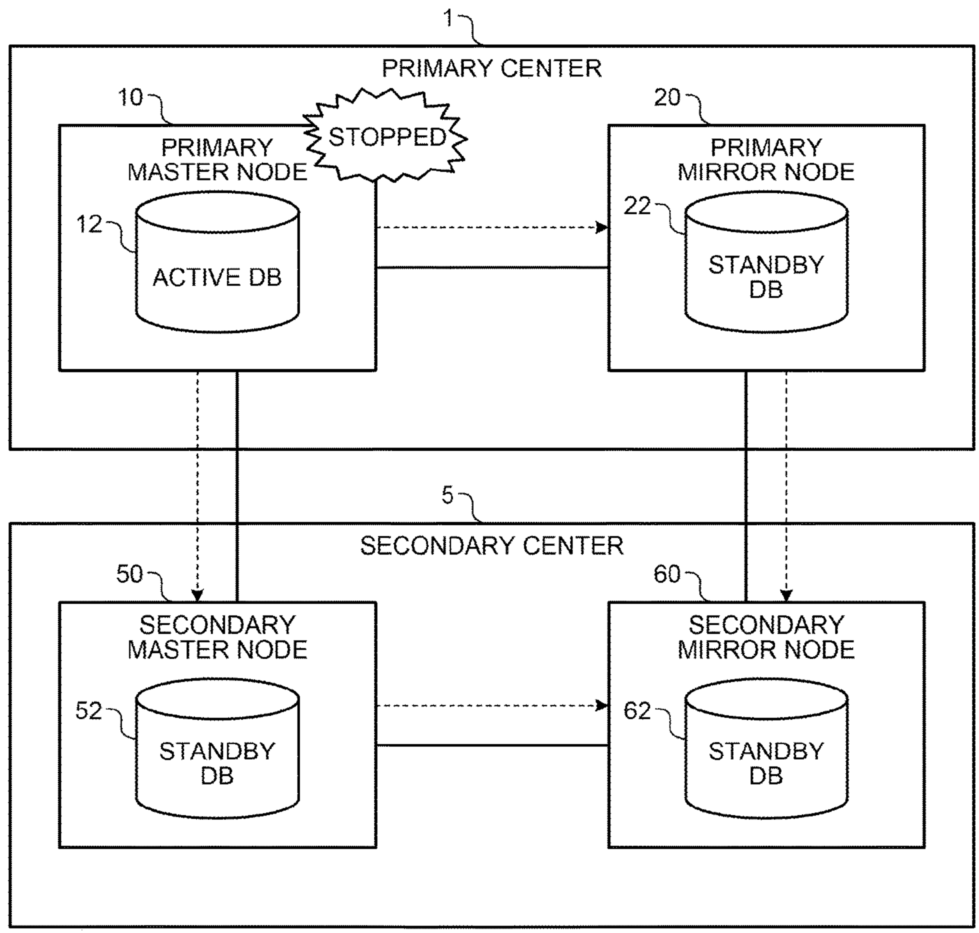

1
PRIMARY CENTER
10
PRIMARY MASTER NODE
STOPPED
12
ACTIVE DB
20
PRIMARY MIRROR NODE
22
STANDBY DB
5
SECONDARY CENTER
50
SECONDARY MASTER NODE
52
STANDBY DB
60
SECONDARY MIRROR NODE
62
STANDBY DB

FIG.17

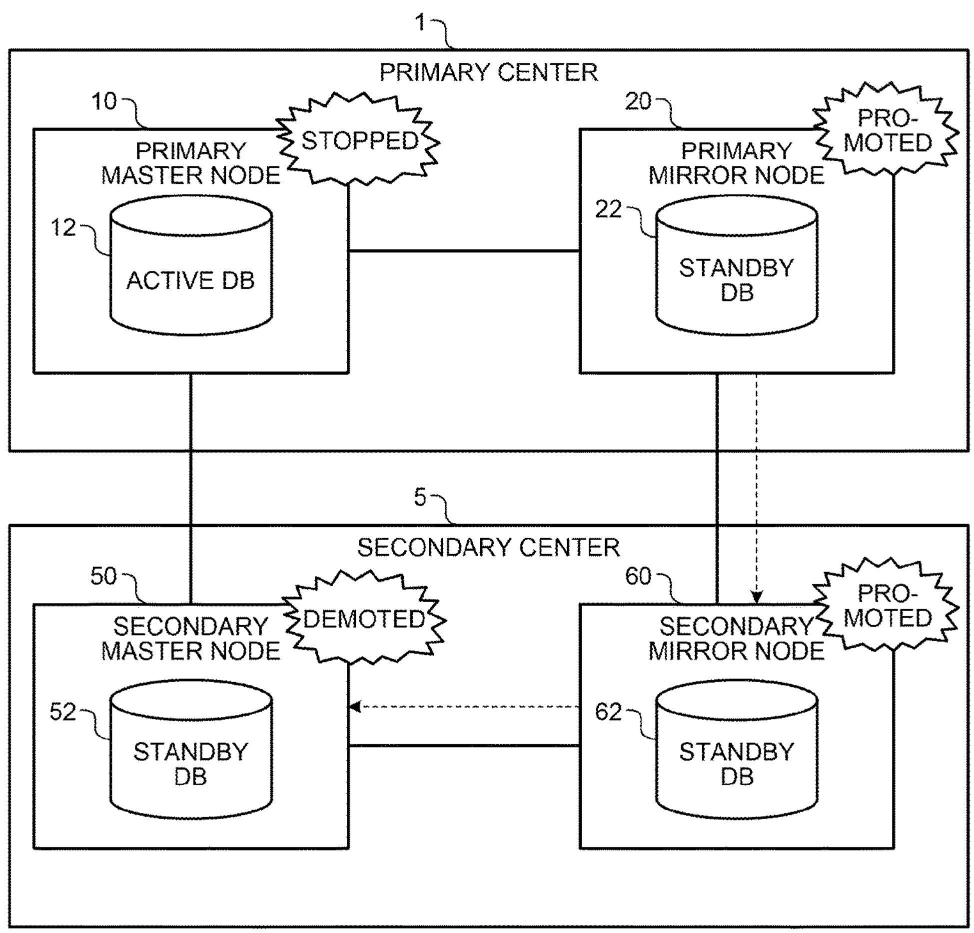

1
PRIMARY CENTER
10
PRIMARY MASTER NODE
STOPPED
12
ACTIVE DB
20
PRIMARY MIRROR NODE
PRO-MOTED
22
STANDBY DB
5
SECONDARY CENTER
50
SECONDARY MASTER NODE
DEMOTED
52
STANDBY DB
60
SECONDARY MIRROR NODE
PRO-MOTED
62
STANDBY DB

FIG.18

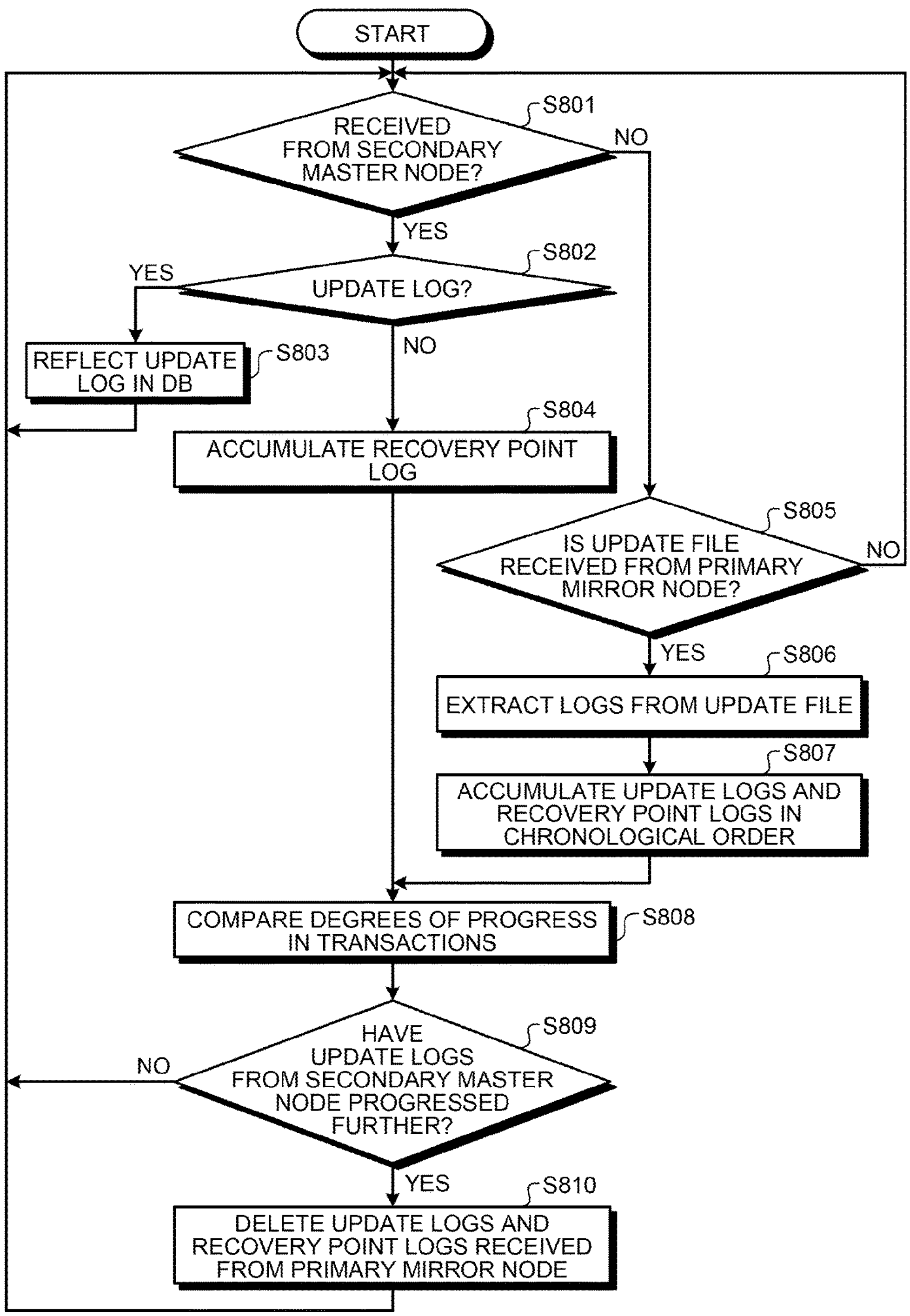

START
RECEIVED FROM SECONDARY MASTER NODE?
S801
NO
YES
UPDATE LOG?
S802
YES
NO
REFLECT UPDATE LOG IN DB
S803
ACCUMULATE RECOVERY POINT LOG
S804
IS UPDATE FILE RECEIVED FROM PRIMARY MIRROR NODE?
S805
NO
YES
EXTRACT LOGS FROM UPDATE FILE
S806
ACCUMULATE UPDATE LOGS AND RECOVERY POINT LOGS IN CHRONOLOGICAL ORDER
S807
COMPARE DEGREES OF PROGRESS IN TRANSACTIONS
S808
HAVE UPDATE LOGS FROM SECONDARY MASTER NODE PROGRESSED FURTHER?
S809
NO
YES
DELETE UPDATE LOGS AND RECOVERY POINT LOGS RECEIVED FROM PRIMARY MIRROR NODE
S810

FIG.19

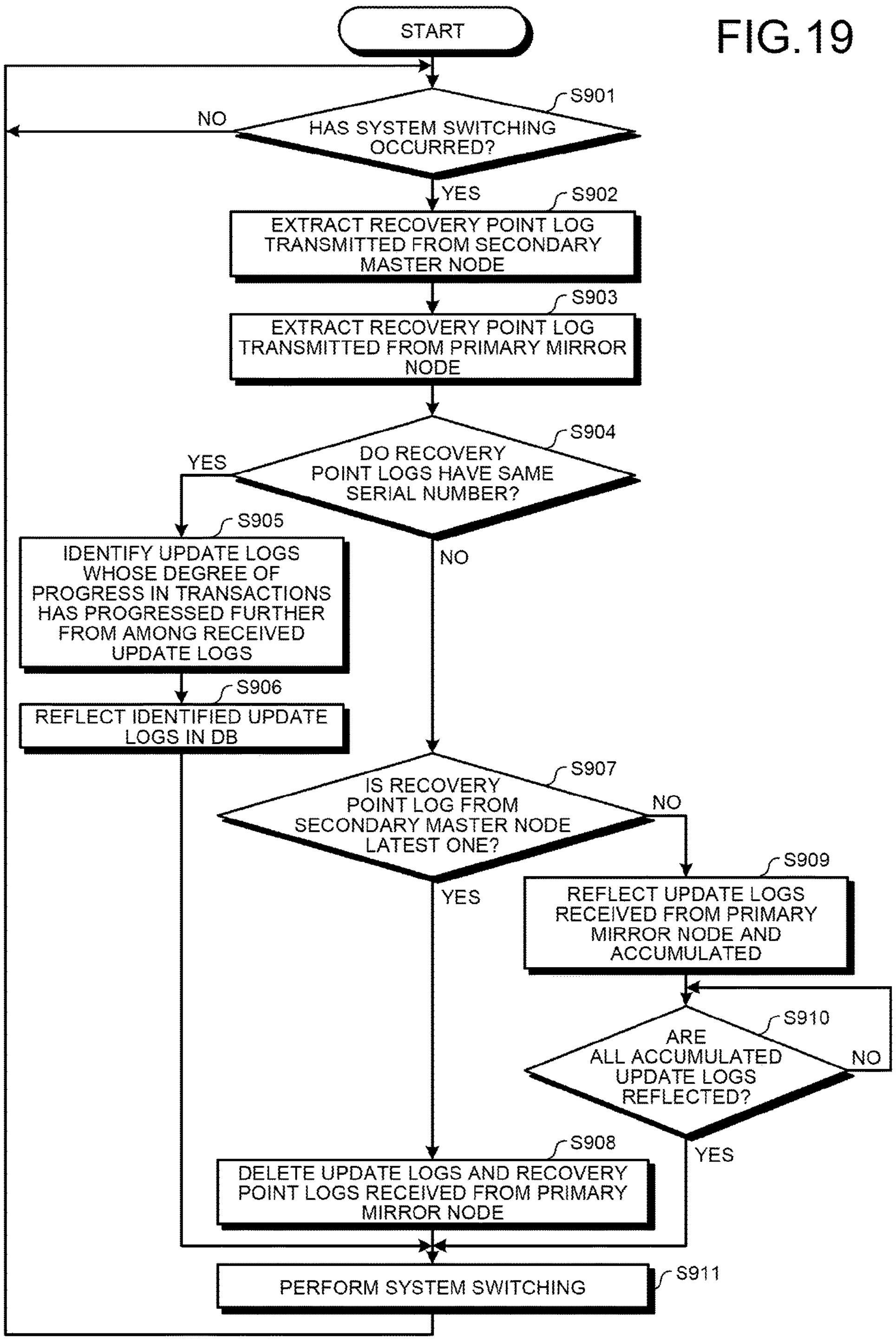
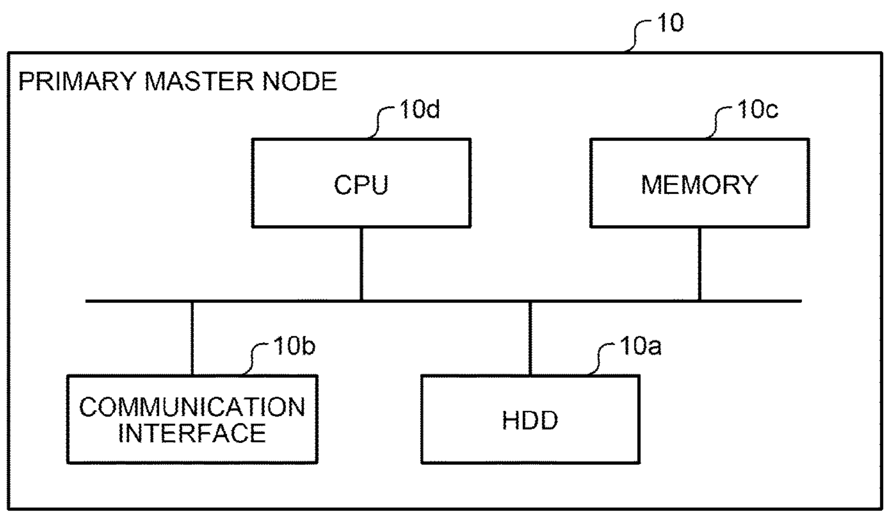

START
S901
HAS SYSTEM SWITCHING OCCURRED?
NO
YES
S902
EXTRACT RECOVERY POINT LOG TRANSMITTED FROM SECONDARY MASTER NODE
S903
EXTRACT RECOVERY POINT LOG TRANSMITTED FROM PRIMARY MIRROR NODE
S904
DO RECOVERY POINT LOGS HAVE SAME SERIAL NUMBER?
YES
NO
S905
IDENTIFY UPDATE LOGS WHOSE DEGREE OF PROGRESS IN TRANSACTIONS HAS PROGRESSED FURTHER FROM AMONG RECEIVED UPDATE LOGS
S906
REFLECT IDENTIFIED UPDATE LOGS IN DB
S907
IS RECOVERY POINT LOG FROM SECONDARY MASTER NODE LATEST ONE?
NO
YES
S909
REFLECT UPDATE LOGS RECEIVED FROM PRIMARY MIRROR NODE AND ACCUMULATED
S910
ARE ALL ACCUMULATED UPDATE LOGS REFLECTED?
NO
YES
S908
DELETE UPDATE LOGS AND RECOVERY POINT LOGS RECEIVED FROM PRIMARY MIRROR NODE
S911
PERFORM SYSTEM SWITCHING

FIG.20


10
PRIMARY MASTER NODE
10d
CPU
10c
MEMORY
10b
COMMUNICATION INTERFACE
10a
HDD

REDUNDANT SYSTEM, REDUNDANCY METHOD, AND COMPUTER-READABLE RECORDING MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2014-127731, filed on Jun. 20, 2014, the entire contents of which are incorporated herein by reference.

FIELD

The embodiments discussed herein are related to a redundant system, a redundancy method, and a redundancy program.

BACKGROUND

It is common that various types of nodes such as a web server, an application server, and a DB (DataBase) server are installed in a data center and each node is made redundant for disasters and failures.

For example, there is known a redundancy technique in which, for a node in a data center, a node in a primary system and a node in a secondary system are prepared, and when the node in the primary system has broken down, the node in the secondary system takes over the processes of the broken-down node in the primary system to continue the processes, instead of the broken-down node in the primary system.

In addition, there is known a technique in which a data center in a secondary system for a backup to a data center in a primary system is provided, and when the data center in the primary system has experienced a disaster, the data center in the secondary system for a backup takes over processes, by which processes performed by the data center in the primary system continue.

[Patent Document 1] Japanese Laid-open Patent Publication No. 2008-134986

However, when a node that transfers logs from the data center in the primary system to the data center in the secondary system has broken down, logs are not transferred to the data center in the secondary system until the node recovers. When the data center in the primary system has experienced a disaster during a period before the broken-down node recovers, data lost occurs.

To inhibit data lost upon the occurrence of both of a breakdown in the node and a data center's experience of a disaster, it is considered to provide a plurality of paths through which logs are transferred between the data centers. However, in that case, a node that receives logs through two paths is present in the data center in the secondary system. In this case, unless the node that receives logs through the two paths appropriately selects which one of the logs through the two paths is to be reflected, an increase in the amount of data lost is caused.

SUMMARY

According to an aspect of the embodiments, a redundant system includes a primary system including a first node and a second node that backs up the first node; and a secondary system including a third node and a fourth node that backs up the third node. The first node in the primary system includes: a processor that executes a first process including transmitting data update information to the second node and

the third node, the data update information being generated in response to a data update in the first node, and the fourth node in the secondary system includes: a processor that executes a second process including: determining a degree of progress in transactions indicated by the data update information obtained through the second node and a degree of progress in transactions indicated by the data update information obtained through the third node, specifying data update information indicating a further progressed transaction, and reflecting the specified data update information to stored data of the fourth node.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram illustrating an exemplary overall configuration of a redundant system according to a first embodiment;

FIG. **2** is a functional block diagram illustrating the functional configurations of nodes in a primary center;

FIG. **3** is a diagram illustrating an example of a user log;

FIG. **4** is a diagram illustrating an example of a control log;

FIG. **5** is a diagram illustrating an example of a recovery point log;

FIG. **6** is a diagram illustrating an example of an update file transmitted by communication between systems;

FIG. **7** is a functional block diagram illustrating the functional configurations of nodes in a secondary center;

FIG. **8** is a diagram describing an example of a comparison between the degrees of progress in transactions made by a secondary mirror node;

FIG. **9** is a flowchart illustrating the flow of a notification process from a primary master node to a primary mirror node;

FIG. **10** is a flowchart illustrating the flow of a notification process from the primary master node to a secondary master node;

FIG. **11** is a flowchart illustrating the flow of an update process performed by the primary mirror node;

FIG. **12** is a flowchart illustrating the flow of a notification process performed by the primary mirror node;

FIG. **13** is a flowchart illustrating the flow of update and notification processes performed by a secondary master node;

FIG. **14** is a flowchart illustrating the flow of an update process performed by the secondary mirror node;

FIG. **15** is a flowchart illustrating the flow of an update process performed by a secondary mirror node according to a second embodiment;

FIG. **16** is a diagram describing an example of the occurrence of a failure in a redundant system according to a third embodiment;

FIG. **17** is a diagram describing an example of system switching of the redundant system according to the third embodiment;

FIG. **18** is a flowchart illustrating the flow of an update process performed by a secondary mirror node according to the third embodiment;

FIG. **19** is a flowchart illustrating the flow of a system switching process performed by the secondary mirror node according to the third embodiment; and

FIG. **20** is a diagram describing an exemplary hardware configuration.

DESCRIPTION OF EMBODIMENTS

Preferred embodiments will be explained with reference to accompanying drawings. Note that the invention is not limited by the embodiments.

[a] First Embodiment

Exemplary Overall Configuration

FIG. **1** is a diagram illustrating an exemplary overall configuration of a redundant system according to a first embodiment. As illustrated in FIG. **1**, the system is a redundant system in which a data center is mirrored by performing a DB quad-redundancy function, i.e., a DB quadruplication function, and includes a primary center **1** and a secondary center **5** which are data centers.

The primary center **1** is a data center including a primary master node **10** and a primary mirror node **20**, and has a redundant configuration for performing DB mirroring. Likewise, the secondary center **5** is a data center including a secondary master node **50** and a secondary mirror node **60**, and has a redundant configuration for performing DB mirroring. The secondary center **5** functions as a backup to the primary center **1**. Note that each node is an example of a DB server, a storage system, etc.

The primary master node **10** is an example of a first node having an active DB **12** to which updates by business operations are made, and is activated as a primary node at normal operation. When the primary master node **10** updates the active DB **12** by a business operation application, etc., the primary master node **10** extracts update information indicating, for example, differences between before and after the update. For example, the primary master node **10** transmits an update log indicating an updated content, to the primary mirror node **20** in synchronization with the update to the active DB **12**. In addition, the primary master node **10** creates an update file including a plurality of update logs, and transmits the update file to the secondary master node **50** at predetermined intervals.

The primary mirror node **20** is an example of a second node having a standby DB **22** which is updated in synchronization with the active DB **12**, and functions as a backup to the primary master node **10** at normal operation. When the primary mirror node **20** receives an update log as update information from the primary master node **10**, the primary mirror node **20** updates the standby DB **22** using the received update log. Thereafter, the primary mirror node **20** creates an update file including update logs received from the primary master node **10**, and transmits the update file to the secondary mirror node **60** at predetermined intervals.

The secondary master node **50** is an example of a third node having a standby DB **52** that stores information equivalent to the active DB **12**. At normal operation, the secondary master node **50** functions as a master node in a secondary system, as primary center **1**'s measures against disasters, etc. When the secondary master node **50** receives an update file as update information from the primary master node **10**, the secondary master node **50** extracts update logs from the received update file and updates the standby DB **52** using the extracted update logs. Thereafter, the secondary master node **50** creates an update file including the plurality of update logs received from the primary master node **10**, and transmits the update file to the secondary mirror node **60** at predetermined intervals.

The secondary mirror node **60** is an example of a fourth node having a standby DB **62** that stores information equivalent to the active DB **12**. At normal operation, the secondary mirror node **60** functions as a mirror node in the secondary system, as primary center **1**'s measures against disasters, etc. The secondary mirror node **60** receives an update file as update information from the primary mirror node **20** and receives an update log from the secondary master node **50**. Then, the secondary mirror node **60** updates the standby DB **62** using either one of the pieces of received update information.

In such a state, the primary master node **10** in a primary system transmits data update information which is generated in response to a data update in the primary master node **10**, to the primary mirror node **20** and the secondary master node **50**.

Then, the secondary mirror node **60** in the secondary center **5** determines the degree of progress in transactions indicated by data update information which is obtained through the primary mirror node **20**, and the degree of progress in transactions indicated by data update information which is obtained through the secondary master node **50**. Thereafter, the secondary mirror node **60** identifies data update information indicating further progressed transactions, and reflects the data update information in stored data of the secondary mirror node **60**.

Specifically, the secondary mirror node **60** which configures a quad-redundant DB receives update information transmitted from the primary master node **10**, through two routes from the primary mirror node **20** and the secondary master node **50**, and identifies and reflects update information indicating transactions whose processes have progressed further. Therefore, the secondary mirror node **60** can suppress data lost in reflection of update information.

Functional Configurations of the Nodes

Next, the functional configurations of the nodes illustrated in FIG. **1** will be described. Although here, as an example, functional configurations in the state of FIG. **1** will be described, the functional configurations are not limited thereto, and the nodes can also have the same functional configuration.

Functional Configuration of the Primary Center

FIG. **2** is a functional block diagram illustrating the functional configurations of the nodes in the primary center. Here, the primary master node **10** and the primary mirror node **20** included in the primary center **1** will be described.

Functional Configuration of the Primary Master Node

As illustrated in FIG. **2**, the primary master node **10** includes a communication control unit **11**, a DB **12**, and a control unit **13**.

The communication control unit **11** is a processor that controls communication with the primary mirror node **20** and with the secondary master node **50**, and is a network interface, for example. For example, the communication control unit **11** transmits update information of the DB **12** to the primary mirror node **20** and the secondary master node **50**.

The DB **12** is a database that stores business operation information, etc., and corresponds to the active DB **12** illustrated in FIG. **1**. Updates by business operations are made to the DB **12**. The DB **12** is provided in a storage apparatus, e.g., a hard disk. The DB **12** corresponds to the active DB **12**.

The control unit **13** is a processor that controls the whole process of the primary master node **10**, and is an example of a processor, for example. The control unit **13** performs the function of implementing a DB redundant system between the primary master node **10** and the primary mirror node **20**, and performs the function of implementing a DB redundant system between the primary master node **10** and the secondary master node **50**. Namely, the control unit **13** executes an application that implements a DB dual-redundancy function in the primary center **1**, and an application that implements DB quad-redundancy function across the centers.

The control unit **13** includes a DB updating unit **14**, an intra-center notifying unit **15**, an inserting unit **16**, and a center-to-center notifying unit **17**. These processors are an example of processes performed by an electronic circuit included in the processor or by the processor.

The DB updating unit **14** is a processor that updates the DB **12**. For example, the DB updating unit **14** updates stored data in the DB **12** along with execution of an application, for example.

The intra-center notifying unit **15** is a processor that transmits update information of the DB **12** to the primary mirror node **20** in the same system, in synchronization with an update to the DB **12**. Specifically, when the DB **12** is updated, the intra-center notifying unit **15** extracts a difference from information obtained before and after the update. Then, the intra-center notifying unit **15** transmits an update log indicating differential information, as update information to the primary mirror node **20**.

Now, an example of an update log will be described. FIG. **3** is a diagram illustrating an example of a user log. FIG. **4** is a diagram illustrating an example of a control log. As illustrated in FIG. **3**, the user log which is an example of an update log is a log indicating DB update information and consists of "a header, a user log display, a variable-length part, a variable-length part **2**, and BC key information".

In the "header", information indicating an update log, a creation date and time, etc., are set. In the "user log display", information indicating that it is a user log is set. The "variable-length part" and the "variable-length part **2**" are information indicating a DB update content, e.g., a specific record position, data before and after the update, and differential information. In the "BC key information", information about DB dual-redundancy between the primary master node **10** and the primary mirror node **20** is set. For example, checksum information or the serial number of the log is set.

As illustrated in FIG. **4**, the control log which is an example of an update log is a log indicating a DB control process, e.g., a rollback process, and consists of "a header, a control log display, and COMMIT specification". In the "header", information indicating an update log, a creation date and time, etc., are set. In the "control log display", information indicating that it is a control log is set. In the "COMMIT specification", information indicating a specific control process, e.g., transaction information, is set.

As described above, when the DB **12** is updated, the intra-center notifying unit **15** creates an update log, such as the above-described user log or control log, according to updated information. Then, the intra-center notifying unit **15** transmits the created update log to the primary mirror node **20**. In addition, the intra-center notifying unit **15** notifies the center-to-center notifying unit **17** of the created update log. Namely, the intra-center notifying unit **15** notifies of DB update information in synchronization with the update to the DB **12**, within the same center.

The inserting unit **16** is a processor that inserts, when update information generated in response to a DB data update in the primary master node **10** is transmitted to the primary mirror node **20** and the secondary master node **50**, one or a plurality of pieces of delimiter information indicating a boundary between update processing units, into both of transmit data.

Specifically, the inserting unit **16** periodically generates a checkpoint which is common determination information between the nodes and which determines an update log arrival status. Then, the inserting unit **16** transmits the checkpoints generated periodically to the primary mirror node **20** and notifies the center-to-center notifying unit **17** of the checkpoints. Note that, for the checkpoint as used herein, a recovery point log which is an example of an update log is used. Note also that, as an example of "periodically", for example, five seconds can be set, but the time interval for generating checkpoints may be changed as appropriate.

FIG. **5** is a diagram illustrating an example of a recovery point log. As illustrated in FIG. **5**, the recovery point log is a log indicating a checkpoint that determines an update log arrival status, and consists of "a header, a control log display, and RP information". In the "header", information indicating an update log, a creation date and time, etc., are set. In the "control log display", information indicating that it is a recovery point log is set. The "RP information" is information identifying a recovery point and includes an "identifier" and a "serial number". The "identifier" is information identifying that it is checkpoint information of the DB quad-redundancy function. The "serial number" is a 23-byte fixed positive number and is a unique serial number in the DB quad-redundant system. For example, a larger number indicates a newer log.

The center-to-center notifying unit **17** is a processor that puts together pieces of update information of the DB **12** and periodically transmits the update information to the secondary master node **50** in a different system. Specifically, the center-to-center notifying unit **17** creates an update file in which update logs obtained from the intra-center notifying unit **15** and recovery point logs obtained from the inserting unit **16** are put together in chronological order, at 10-second intervals, for example, and transmits the update file to the secondary master node **50**. Namely, between different centers, the center-to-center notifying unit **17** generates update information in which DB update information and checkpoints are periodically put together, and notifies of the update information asynchronously with an update to the DB **12**.

FIG. **6** is a diagram illustrating an example of an update file transmitted by communication between the systems. As illustrated in FIG. **6**, the update file consists of update logs and a recovery point log. In the example of FIG. **6**, the update file includes an update log **1**, an update log **2**, a recovery point log **1**, etc., and indicates that the logs are created in this order. Note that the update log **1** and the update log **2** correspond to the above-described user log or control log, and the recovery point log **1** corresponds to the above-described recovery point log.

Functional Configuration of the Primary Mirror Node

As illustrated in FIG. **2**, the primary mirror node **20** includes a communication control unit **21**, a DB **22**, and a control unit **23**.

The communication control unit **21** is a processor that controls communication with the primary master node **10** and with the secondary mirror node **60**, and is a network interface, for example. For example, the communication control unit **21** receives DB update information from the primary master node **10** and transmits the DB update information to the secondary mirror node **60**.

The DB **22** is a database that stores, for example, the same business operation information as that in the DB **12** of the primary master node **10**, and corresponds to the standby DB **22** illustrated in FIG. **1**. The DB **22** is updated in synchronization with the DB **12**. Note that the DB **22** is provided in a storage apparatus, e.g., a hard disk. The DB **22** corresponds to the standby DB **22**.

The control unit **23** is a processor that controls the whole process of the primary mirror node **20**, and is an example of a processor, for example. The control unit **23** performs the function of implementing a DB redundant system between the primary master node **10** and the primary mirror node **20**, and performs the function of implementing a DB redundant system between the primary mirror node **20** and the secondary mirror node **60**. Namely, the control unit **23** executes an application that implements a DB dual-redundancy function in the primary center **1**, and an application that implements DB quad-redundancy function across the centers.

The control unit **23** includes a receiving unit **24**, a DB updating unit **25**, and a center-to-center notifying unit **26**. These processors are an example of processes performed by an electronic circuit included in the processor or by the processor.

The receiving unit **24** is a processor that receives update information of the DB **12** from the primary master node **10**. Specifically, the receiving unit **24** receives an update log which is synchronized with an update to the DB **12** of the primary master node **10**, and notifies the DB updating unit **25** and the center-to-center notifying unit **26** of the update log. In addition, when the receiving unit **24** receives a recovery point log, the receiving unit **24** notifies the center-to-center notifying unit **26** of the recovery point log.

The DB updating unit **25** is a processor that updates the DB **22** using data update information notified from the primary master node **10**. For example, the DB updating unit **25** extracts, for example, a record to be updated and updated data from a variable-length part, etc., in a received update log, and updates the DB **22** according to the extracted information. The DB updating unit **25** updates the DB **22** every time an update log is received. As a result, the DB **22** can be synchronized with the DB **12** of the primary master node **10** and functions as a mirroring DB.

The center-to-center notifying unit **26** is a processor that puts together pieces of update information of the DB **22** and periodically transmits the update information to the secondary mirror node **60** in a different system. Specifically, the center-to-center notifying unit **26** creates an update file in which update logs and recovery point logs received from the primary master node **10** are put together in chronological order, at 10-second intervals, for example, and transmits the update file to the secondary mirror node **60**. For example, the center-to-center notifying unit **26** creates an update file illustrated in FIG. **6** and transmits the update file to the secondary mirror node **60**.

Functional Configuration of the Secondary Center

FIG. **7** is a functional block diagram illustrating the functional configurations of the nodes in the secondary center. Here, the secondary master node **50** and the secondary mirror node **60** included in the secondary center **5** will be described.

Functional Configuration of the Secondary Master Node

As illustrated in FIG. **7**, the secondary master node **50** includes a communication control unit **51**, a DB **52**, and a control unit **53**.

The communication control unit **51** is a processor that controls communication with the primary master node **10** and with the secondary mirror node **60**, and is a network interface, for example. For example, the communication control unit **51** receives an update file including various types of update logs, as update information of the DB **12** of the primary master node **10**, from the primary master node **10**. In addition, the communication control unit **51** transmits the update logs of the DB **12** of the primary master node **10** to the secondary mirror node **60**.

The DB **52** is a database that stores business operation information, etc., and corresponds to the standby DB **52** illustrated in FIG. **1**. The DB **52** is updated asynchronously with an update to the DB **12**, using update information notified from the primary master node **10**. Note that the DB **52** is provided in a storage apparatus, e.g., a hard disk.

The control unit **53** is a processor that controls the whole process of the secondary master node **50**, and is an example of a processor, for example. The control unit **53** executes an application that implements the entire DB quad-redundant system across the centers illustrated in FIG. **1**, and executes an application that implements the DB dual-redundancy function in the secondary center **5**. The DB **52** corresponds to the standby DB **52**.

The control unit **53** includes a receiving unit **54**, a DB updating unit **55**, and an intra-center notifying unit **56**. These processors are an example of processes performed by an electronic circuit included in the processor or by the processor.

The receiving unit **54** is a processor that receives update information of the DB **12** from the primary master node **10**. Specifically, the receiving unit **54** receives an update file including update logs at predetermined intervals. Then, the receiving unit **54** outputs the received update file to the DB updating unit **55**.

The DB updating unit **55** is a processor that updates the DB **52** according to data update information notified from the primary master node **10**. For example, the DB updating unit **55** extracts, from an update file received by the receiving unit **54**, various types of logs included in the update file.

Then, the DB updating unit **55** identifies user logs and control logs among the extracted logs. Thereafter, the DB updating unit **55** reflects data updates identified by the respective logs, in the DB **52** in chronological order in which the logs are created. In addition, when the DB updating unit **55** extracts various types of logs from the update file, the DB updating unit **55** outputs the extracted logs to the intra-center notifying unit **56** in chronological order.

For example, assuming that an update file of FIG. **6** is received, the DB updating unit **55** extracts an update log **1**, an update log **2**, and a recovery point log **1** from the update file. Then, the DB updating unit **55** first reflects a data update identified by the update log **1** in the DB **52** and then reflects a data update identified by the update log **2** in the DB **52**. Meanwhile, the DB updating unit **55** outputs the extracted update log **1**, update log **2**, and recovery point log **1** to the intra-center notifying unit **56**.

The intra-center notifying unit **56** is a processor that transmits update information of data reflected in the DB **52** to the secondary mirror node **60**. Specifically, the intra-center notifying unit **56** transmits update logs and recovery point logs which are received from the primary master node **10**, to the secondary mirror node **60** in chronological order in which the logs are created.

Describing using the above-described example, the intra-center notifying unit **56** receives an update log **1**, an update log **2**, and a recovery point log **1** in turn from the DB updating unit **55**. Then, the intra-center notifying unit **56** first transmits the update log **1** to the secondary mirror node **60**, and then transmits the update log **2** to the secondary mirror node **60** and transmits the last recovery point log **1** to the secondary mirror node **60**.

Functional Configuration of the Secondary Mirror Node

As illustrated in FIG. **7**, the secondary mirror node **60** includes a communication control unit **61**, a DB **62**, a buffer **63**, and a control unit **64**.

The communication control unit **61** is a processor that controls communication with the primary mirror node **20** and with the secondary master node **50**, and is a network interface, for example. For example, the communication control unit **61** receives data update information from both of the primary mirror node **20** and the secondary master node **50**.

The DB **62** is a database that stores business operation information, etc., and corresponds to the standby DB **62** illustrated in FIG. **1**. The DB **62** is updated asynchronously with an update to the DB **12** of the primary master node **10**, using update information notified from the primary master node **10**. On the other hand, the DB **62** is updated in synchronization with an update to the DB **52** of the secondary master node **50**. Note that the DB **62** is provided in a storage apparatus, e.g., a hard disk. The DB **62** corresponds to the standby DB **62**.

The buffer **63** is a storage area that temporarily stores update information received from the primary mirror node **20** by communication between the centers and update information received from the secondary master node **50** by communication within the center. Note that the buffer **63** is provided in a storage apparatus, e.g., a hard disk or a memory.

The control unit **64** is a processor that controls the whole process of the secondary mirror node **60**, and is an example of a processor, for example. The control unit **64** executes an application that implements the entire DB quad-redundant system across the centers illustrated in FIG. **1**, and executes an application that implements the DB dual-redundancy function in the secondary center **5**.

The control unit **64** includes an intra-center receiving unit **65**, a center-to-center receiving unit **66**, an identifying unit **67**, and a DB updating unit **68**. These processors are an example of processes performed by an electronic circuit included in the processor or by the processor.

The intra-center receiving unit **65** is a processor that receives data update information from the secondary master node **50**. Specifically, the intra-center receiving unit **65** receives update logs and recovery point logs from the secondary master node **50** and stores the update logs and the recovery point logs in the buffer **63** in chronological order of log creation date and time. Describing using the above-described example, the intra-center receiving unit **65** receives an update log **1**, an update log **2**, and a recovery point log **1** in turn from the secondary master node **50** and stores the update log **1**, the update log **2**, and the recovery point log **1** in the buffer **63** in the order of reception.

The center-to-center receiving unit **66** is a processor that receives data update information from the primary mirror node **20**. Specifically, the center-to-center receiving unit **66** receives an update file including update logs and recovery point logs, from the primary mirror node **20**. Then, the center-to-center receiving unit **66** extracts various types of logs from the update file and stores the logs in the buffer **63** in the order of creation date and time.

The identifying unit **67** is a processor that identifies update information whose transactions have progressed further from among update information of the DB **12** obtained through the secondary master node **50** and update information of the DB **12** obtained from the primary mirror node **20**. Specifically, the identifying unit **67** identifies update information whose transactions have progressed further, according to the number of transactions indicated by update information later than the last recovery point log included in the update information.

Now, an example of a determination of the degrees of progress in transactions will be described. FIG. **8** is a diagram describing an example of a comparison between the degrees of progress in transactions made by the secondary mirror node **60**. A "R(number)" illustrated in FIG. **8** indicates a recovery point log, and "(number)" indicates the order of receiving the recovery point log. Likewise, a "U(number)" indicates an update log such as a user log or a control log, and "(number)" indicates the order of receiving the update log.

In the example of FIG. **8**, the identifying unit **67** identifies that update information is received from the primary mirror node **20** in order of R(**1**), U(**1**), U(**2**), R(**2**), U(**3**), U(**4**), R(**3**), and U(**5**). In addition, the identifying unit **67** identifies that update information is received from the secondary master node **50** in order of R(**1**), U(**1**), U(**2**), R(**2**), U(**3**), U(**4**), R(**3**), U(**5**), U(**6**), and U(**7**), by extracting various types of logs from an update file.

In this case, the identifying unit **67** determines, for the update information from the primary mirror node **20**, that there is only one update log "U(**5**)" later than "R(**3**)" which is the last recovery point log in the update information. On the other hand, the identifying unit **67** determines, for the update information from the secondary master node **50**, that there are three update logs, "U(**5**)", "U(**6**)", and "U(**7**)", later than "R(**3**)" which is the last recovery point log in the update information.

That is, for the update information from the primary mirror node **20** and the update information from the secondary master node **50**, the identifying unit **67** identifies "U(**6**)" and "U(**7**)" as differences between the degrees of progress in transactions. As a result, the identifying unit **67** identifies that the transactions of the update information from the secondary master node **50** have progressed further, and thus notifies the DB updating unit **68** of the update information.

The DB updating unit **68** is a processor that updates the DB **62** using data update information whose transactions have progressed further. Specifically, the DB updating unit **68** extracts data update information from update logs notified from the identifying unit **67** and reflects the data update information in the DB **62**. In the case of the above-described example, the DB updating unit **68** sequentially reads update logs received by the intra-center receiving unit **65** from the buffer **63** in chronological order, and sequentially reflects data updates identified by the respective logs, in the DB **62**.

Flow of Processes

Next, processes performed by each node will be described. Here, a DB update process and an update information notification process which are performed by each node will be described. Note that although here, as an example, an example is described in which a checkpoint (recovery point log) is created after a DB update, the configuration is not limited thereto. For example, a DB update process and a checkpoint creation process can be performed in parallel or can also be performed using different flowcharts.

Notification Process from the Primary Master Node **10** to the Primary Mirror Node **20**

FIG. **9** is a flowchart illustrating the flow of a notification process from the primary master node to the primary mirror node.

As illustrated in FIG. **9**, if an update to the DB **12** occurs (S**101**: Yes), the DB updating unit **14** of the primary master node **10** updates the DB **12** (S**102**). Subsequently, the intra-center notifying unit **15** extracts a difference between before and after the update to the updated DB **12** (S**103**), creates an update log, and transmits the update log to the primary mirror node **20** (S**104**).

On the other hand, if it is checkpoint creation timing (S**105**: Yes), the inserting unit **16** creates a recovery point log including the serial number of a checkpoint (S**106**) and transmits the recovery point log to the primary mirror node **20** (S**107**). Note that if it is not checkpoint creation timing (S**105**: No), processing returns to S**101** and the processes at and after S**101** are performed.

Notification Process from the Primary Master Node **10** to the Secondary Master Node **50**

FIG. **10** is a flowchart illustrating the flow of a notification process from the primary master node to the secondary master node.

As illustrated in FIG. **10**, if an update to the DB **12** occurs (S**201**: Yes), the DB updating unit **14** of the primary master node **10** updates the DB **12** (S**202**). Thereafter, the center-to-center notifying unit **17** extracts and accumulates a difference between before and after the update to the updated DB **12** (S**203**).

Meanwhile, if it is checkpoint creation timing (S**204**: Yes), the inserting unit **16** creates and accumulates a recovery point log including the serial number of a checkpoint (S**205**). Note that if it is not checkpoint creation timing (S**204**: No), S**205** is not performed but S**206** is performed.

Thereafter, if notification timing to the secondary master node **50** has reached (S**206**: Yes), the center-to-center notifying unit **17** creates an update file in which accumulated update logs and recovery point logs are described in the order of creation (S**207**). Then, the center-to-center notifying unit **17** transmits the created update file to the secondary master node **50** (S**208**). Note that if it is not notification timing to the secondary master node **50** (S**206**: No), processing returns to S**201** and the processes at and after S**201** are performed.

Update Process of the Primary Mirror Node **20**

FIG. **11** is a flowchart illustrating the flow of an update process performed by the primary mirror node. As illustrated in FIG. **11**, if the receiving unit **24** of the primary mirror node **20** receives information from the primary master node **10** (S**301**: Yes), the receiving unit **24** determines whether the received information is an update log (S**302**).

Subsequently, if the received information is an update log (S**302**: Yes), the DB updating unit **25** updates the DB **22** according to the received update log (S**303**) and accumulates the update log used for the update (S**304**).

On the other hand, if the received information is not an update log but is a recovery point log (S**302**: No), the DB updating unit **25** accumulates the received recovery point log in a storage unit or the like (S**305**).

Notification Process of the Primary Mirror Node **20**

FIG. **12** is a flowchart illustrating the flow of a notification process performed by the primary mirror node. As illustrated in FIG. **12**, if notification timing has reached (S**401**: Yes), the center-to-center notifying unit **26** of the primary mirror node **20** reads accumulated update logs and recovery point logs (S**402**).

Thereafter, the center-to-center notifying unit **26** rearranges the read logs in the order of creation to create an update file (S**403**) and transmits the created update file to the secondary mirror node **60** in the secondary center **5** (S**404**).

Processes of the Secondary Master Node **50**

FIG. **13** is a flowchart illustrating the flow of update and notification processes performed by the secondary master node. As illustrated in FIG. **13**, if an update file is received (S**501**: Yes), the DB updating unit **55** of the secondary master node **50** extracts logs included in the update file (S**502**).

Subsequently, the DB updating unit **55** sequentially reflects update logs among the obtained logs, in the DB **52** in chronological order of creation time (S**503**), and repeats such a process until reflection of all of the extracted update logs has been completed (S**504**: No).

Then, if reflection of all of the extracted update logs has been completed (S**504**: Yes), the intra-center notifying unit **56** sequentially transmits the update logs and recovery point logs which are obtained from the update file, in chronological order of creation time to the secondary mirror node **60** (S**505**). Thereafter, the intra-center notifying unit **56** repeats the process until transmission of all of the logs obtained from the update file has been completed (S**506**: No). If transmission of all of the logs has been completed (S**506**: Yes), processing returns to S**501** and the processes at and after S**501** are repeated.

Processes of the Secondary Mirror Node **60**

FIG. **14** is a flowchart illustrating the flow of an update process performed by the secondary mirror node. As illustrated in FIG. **14**, if the intra-center receiving unit **65** of the secondary mirror node **60** receives an update log or a recovery point log from the secondary master node **50** (S**601**: Yes), the intra-center receiving unit **65** accumulates the received update log or recovery point log in the buffer **63** in the order of reception (S**602**).

On the other hand, if the center-to-center receiving unit **66** receives an update file (S**603**: Yes) instead of an update log or a recovery point log (S**601**: No), the center-to-center receiving unit **66** extracts logs from the update file (S**604**). Subsequently, the center-to-center receiving unit **66** accumulates the obtained update logs and recovery point logs in the buffer **63** in chronological order of log creation time (S**605**).

Thereafter, until the timing of reflection in the DB **62** has reached (S**606**: No), processing returns to S**601** and the processes at and after S**601** are performed. Then, if the timing of reflection in the DB **62** has reached (S**606**: Yes), the identifying unit **67** identifies update logs whose transactions have progressed further from among the update logs received through two routes (S**607**).

Thereafter, the DB updating unit **68** reflects the update logs whose transactions have progressed further and which are identified by the identifying unit **67**, in the DB **62** in the order in which the update logs are created (S**608**).

As described above, when the primary master node **10** transmits update information of the DB **12**, the primary master node **10** periodically transmits a checkpoint. The secondary mirror node **60** receives update information and check points through two routes. Then, the secondary mirror node **60** can update the DB **62** using update information whose transactions have progressed further with reference to a check point. As a result, the secondary mirror node **60** can suppress data lost of update information for updating the DB **62**.

In addition, when the primary master node **10** has updated the DB **12**, the primary master node **10** transmits an update log to the primary mirror node **20**. As a result, the primary mirror node **20** can allow the state of the DB **22** to be synchronized with that of the DB **12**. In addition, the primary master node **10** periodically transmits an update file in which logs having been used to update the DB **12** are put together, to the secondary master node **50**. As a result, the secondary master node **50** can update the DB **52** with reduced update time of the DB **12** and a reduced time lag.

Therefore, even when switching occurs within a system due to the occurrence of a failure, business operations can continue without delay, using a standby DB. In addition, even when switching occurs between the systems due to the occurrence of a failure in the primary center, business operations can continue without delay, using the DBs in the secondary center.

[b] Second Embodiment

Meanwhile, the first embodiment describes an example in which, for update logs received through each route, the numbers of update logs obtained after the latest recovery point are compared with each other to determine the degrees of progress in transactions, by which the latest update logs are identified. However, the configuration is not limited thereto.

For example, first, recovery point logs are compared with each other. If the recovery point logs are the same, the degrees of progress in transactions can also be determined. Hence, in a second embodiment, as another example of identifying the latest update logs, an example will be described in which first, recovery point logs are compared with each other, and when the recovery point logs are the same, the degrees of progress in transactions are determined.

FIG. **15** is a flowchart illustrating the flow of an update process performed by a secondary mirror node. As illustrated in FIG. **15**, if an intra-center receiving unit **65** of a secondary mirror node **60** receives an update log or a recovery point log from a secondary master node (S**701**: Yes), the intra-center receiving unit **65** accumulates the received update log or recovery point log in a buffer **63** in the order of reception (S**702**).

On the other hand, if a center-to-center receiving unit **66** receives an update file (S**703**: Yes) instead of an update log or a recovery point log (S**701**: No), the center-to-center receiving unit **66** extracts logs from the update file (S**704**). Subsequently, the center-to-center receiving unit **66** accumulates the obtained update logs and recovery point logs in the buffer **63** in chronological order of log creation time (S**705**).

Thereafter, until the timing of reflection in a DB **62** has reached (S**706**: No), processing returns to S**701** and the processes at and after S**701** are performed. Then, if the timing of reflection in the DB **62** has reached (S**706**: Yes), an identifying unit **67** determines whether the accumulated recovery point logs for the two systems have the same serial number (S**707**). For example, the identifying unit **67** compares the serial number of the latest recovery point log received by the intra-center receiving unit **65** with the serial number of the latest recovery point log received by the center-to-center receiving unit **66**.

Then, if the recovery point logs have the same serial number (S**707**: Yes), the identifying unit **67** identifies, from the update logs received through two routes, update logs whose transactions have progressed further (S**708**). Thereafter, a DB updating unit **68** reflects the update logs whose transactions have progressed further and which are identified by the identifying unit **67**, in the DB **62** in the order in which the update logs are created (S**709**).

On the other hand, if the recovery point logs have different serial numbers (S**707**: No), the identifying unit **67** identifies update logs received through a route with a newer serial number of the recovery point log, as update logs whose processes have progressed further (S**710**). Thereafter, the DB updating unit **68** reflects each of the update logs whose processes have progressed further and which are identified by the identifying unit **67**, in the DB **62** in the order of creation (S**711**).

As such, when the secondary mirror node **60** can determine, by recovery point logs, which update log is newer, the secondary mirror node **60** omits a determination by the degrees of progress in transactions, and reflects the newer update log in the DB **62**. In addition, when the secondary mirror node **60** is unable to determine, by recovery point logs, which update log is newer, the secondary mirror node **60** performs a determination by the degrees of progress in transactions. As a result, the secondary mirror node **60** can update the DB **62** more quickly, enabling to reduce the number of data losses for when system switching occurs with update logs not reflected.

[c] Third Embodiment

Next, a third embodiment describes system switching performed when a failure occurs in a primary master node **10** in a DB quad-redundant system described in the first embodiment.

In addition, although the first embodiment describes an example in which a secondary mirror node **60** accumulates update logs received through each route and identifies and reflects, at predetermined timing, update information whose transactions have progressed further, the method of reflection in a DB is not limited thereto.

For example, the secondary mirror node **60** accumulates update information received from a primary mirror node **20**, and reflects update information received from a secondary master node **50**, in the DB **62**. Then, when system switching occurs, the secondary mirror node **60** determines whether the update information received from the primary mirror node **20** is the latest information. If the information is the latest one, the secondary mirror node **60** reflects the update information and then can perform system switching.

Hence, the third embodiment describes a DB update process of the secondary mirror node which is different than that of the first embodiment, and a system switching process.

Overall Configuration

FIG. **16** is a diagram describing an example of the occurrence of a failure in a redundant system according to the third embodiment. As illustrated in FIG. **16**, the overall configuration is the same as that of FIG. **1** and thus a detailed description thereof is omitted.

In addition, dotted lines illustrated in FIG. **16** indicate the flow of update logs and recovery point logs. Specifically, as in the first embodiment, the primary master node **10** transmits update logs and recovery point logs to both of the primary mirror node **20** and the secondary master node **50**. The primary mirror node **20** and the secondary master node **50** transmit the update logs and recovery point logs which are received from the primary master node **10**, to the secondary mirror node **60**. The secondary mirror node **60** receives the update logs and recovery point logs of the primary master node **10** through two routes.

In such a state, when, as illustrated in FIG. **16**, the primary master node **10** is stopped due to a failure, etc., system switching occurs. Note that, for a trigger for the occurrence of system switching, an administrator's terminal may notify each node, or the primary master node **10** may notify the primary mirror node **20** of the occurrence of a failure. As another example, it is also possible that the primary mirror node **20** performs alive monitoring by periodically issuing ping (Packet Internet Groper) to the primary master node **10**, and when the primary mirror node **20** has not been able to detect a response, system switching is performed.

FIG. **17** is a diagram describing an example of system switching of the redundant system according to the third embodiment. When, as illustrated in FIG. **17**, the primary master node **10** is stopped, the primary mirror node **20** is promoted to a master node in a primary system, the secondary mirror node **60** is promoted to a master node in a secondary system, and the secondary master node **50** is demoted to a mirror node in the secondary system. As a result, a standby DB **22** of the primary mirror node **20** is promoted to an active DB, and thus, the DB **22** is updated along with the execution of an application.

Then, when the standby DB **22** is updated, the primary mirror node **20** transmits an update file including update logs and recovery point logs to the secondary mirror node **60**. The secondary mirror node **60** updates a standby DB **62** according to the update logs included in the received update file. Then, the secondary mirror node **60** transmits the update logs and recovery point logs included in the received update file to the secondary master node **50**. The secondary master node **50** updates a standby DB **52** according to the received update logs.

Update Process of the Secondary Mirror Node

FIG. **18** is a flowchart illustrating the flow of an update process performed by the secondary mirror node according to the third embodiment. Note that the process described here is an update process performed before system switching.

As illustrated in FIG. **18**, if an intra-center receiving unit **65** receives information from the secondary master node **50** (S**801**: Yes), a DB updating unit **68** of the secondary mirror node **60** determines whether the received information is an update log (S**802**).

Then, if the received information is an update log (S**802**: Yes), the DB updating unit **68** reflects the received update log in the DB **62** and thereby updates the DB **62** (S**803**). On the other hand, if the received information is not an update log but is a recovery point log (S**802**: No), the DB updating unit **68** accumulates the recovery point log in a buffer **63** or the like (S**804**).

In addition, if, at S**801**, a center-to-center receiving unit **66** receives an update file from the primary mirror node **20** instead of from the secondary master node **50** (S**801**: No and S**805**: Yes), the center-to-center receiving unit **66** extracts logs from the update file (S**806**). Then, the center-to-center receiving unit **66** accumulates the obtained update logs and recovery point logs in the buffer **63** in chronological order of log creation time (S**807**).

Thereafter, the DB updating unit **68** compares, at prespecified intervals, the degrees of progress in transactions, using update logs and recovery point logs stored in the buffer **63** (S**808**).

Then, if the DB updating unit **68** determines that the transactions of the update logs from the secondary master node **50** have progressed further (S**809**: Yes), the DB updating unit **68** performs S**810**. Specifically, the DB updating unit **68** deletes the update logs and recovery point logs received from the primary mirror node **20**, from the buffer **63** (S**810**).

On the other hand, if the DB updating unit **68** determines that the transactions of the update logs from the primary mirror node **20** have progressed further (S**809**: No), the DB updating unit **68** repeats the processes at and after S**801**, with the update logs and recovery point logs received from the primary mirror node **20** remaining in the buffer **63**.

System Switching Process of the Secondary Mirror Node

FIG. **19** is a flowchart illustrating the flow of a system switching process performed by the secondary mirror node according to the third embodiment. As illustrated in FIG. **19**, the DB updating unit **68** of the secondary mirror node **60**, if system switching occurs (S**901**: Yes), extracts the latest recovery point log transmitted from the secondary master node **50** and the latest recovery point log transmitted from the primary mirror node **20** from the buffer **63** (S**902** and S**903**).

Giving an example, the DB updating unit **68** of the secondary mirror node **60** detects the occurrence of system switching by receiving a switching notification from the primary mirror node **20** having detected a stop of the primary master node **10** or by receiving a switching instruction from the administrator's terminal.

Then, if the recovery point logs have the same serial number (S**904**: Yes), an identifying unit **67** identifies, from the update logs received through the two routes, update logs whose transactions have progressed further (S**905**). Thereafter, the DB updating unit **68** reflects the update logs whose transactions have progressed further and which are identified by the identifying unit **67**, in the DB **62** in the order in which the update logs are created (S**906**).

On the other hand, if the recovery point logs have different serial numbers (S**904**: No), the identifying unit **67** determines whether the serial number of the recovery point log from the secondary master node **50** is newer, i.e., the recovery point log from the secondary master node **50** is the latest one (S**907**).

Then, if the recovery point log from the secondary master node **50** is the latest one (S**907**: Yes), the identifying unit **67** deletes the update logs and recovery point logs received from the primary mirror node **20**, from the buffer **63** (S**908**).

On the other hand, if the recovery point log from the secondary master node **50** is not the latest one but the recovery point log from the primary mirror node **20** is the latest one (S**907**: No), the DB updating unit **68** performs S**909**.

Specifically, the DB updating unit **68** reflects the update logs received from the primary mirror node **20** and accumulated in the buffer **63**, in the DB **62** and thereby updates the DB **62** (S**909**), and repeatedly performs such a process until reflection of all of the accumulated update logs has been completed (S**910**: No).

Thereafter, if reflection of all of the accumulated update logs at S**910** has been completed (S**910**: Yes) or when performance of S**906** has been completed, the DB updating unit **68** performs system switching (S**911**). That is, the DB updating unit **68** performs the same processes as those performed by the secondary master node **50** which are described in the first embodiment, and behaves as a master node in the secondary system.

At this time, the DB updating unit **68** of the secondary mirror node **60** notifies the secondary master node **50** of the occurrence of system switching, and the secondary master node **50** performs the functions of a mirror node in the secondary system. That is, the secondary master node **50** behaves as a general DB dual-redundant mirror DB.

As such, in the DB quad-redundant system, even when the primary master node **10** is stopped, since each node can operate by automatically changing its role, business operations can continue, leading to an improvement in reliability.

In addition, since the secondary mirror node **60** can sequentially reflect update logs received from the secondary master node **50** until system switching occurs, the state of the DB **62** can be maintained to be more latest compared to the first embodiment. Therefore, even when the secondary master node **50** is stopped, the secondary mirror node **60** can maintain the functions as a backup while suppressing data lost.

[d] Fourth Embodiment

Although the embodiments of the present invention have been described so far, in addition to the above-described embodiments, the present invention may be implemented in various different modes.

Checkpoint

Although the above-described embodiments describe an example in which a recovery point log including a unique serial number in a system is used as a checkpoint, the configuration is not limited thereto. For example, a recovery point log including a date and time, a time, etc., can also be used. That is, various information can be used as long as the information can specify a unique order such as an ascending order or a descending order in the system.

System

In addition, of the processes described in the embodiments, all or some of those processes described as being performed automatically can also be performed manually. Alternatively, all or some of those processes described as being performed manually can also be performed automatically by publicly known methods. In addition, information including processing procedures, control procedures, specific names, various types of data, and parameters illustrated in the above-described document and drawings can be arbitrarily changed unless otherwise indicated.

In addition, each component of each apparatus illustrated in the drawings is functionally conceptual and thus does not always physically configured as illustrated in the drawings. Namely, a specific mode of separation or integration of each apparatus is not limited to that illustrated in the drawings. That is, all or some of the components can be configured by separating or integrating them functionally or physically in any unit, according to various types of loads, the status of use, etc. Furthermore, all or arbitrary ones of processing functions performed by each apparatus can be implemented by a CPU and a program analyzed and executed by the CPU or implemented by wired logic hardware.

Hardware

FIG. **20** is a diagram describing an exemplary hardware configuration. Since the nodes illustrated in FIG. **1** have the same hardware configuration, here, as an example, a description is made using the primary master node **10** as an example.

As illustrated in FIG. **20**, the primary master node **10** includes an HDD (Hard Disk Drive) **10***a*, a communication interface **10***b*, a memory **10***c*, and a CPU (Central Processing Unit) **10***d*. In addition, the components illustrated in FIG. **20** are connected to each other by a bus or the like. Note that the hardware illustrated here is an example and thus the primary master node **10** may include other hardware, e.g., a graphics interface and a mouse.

The HDD **10***a* stores a program that causes the functions illustrated in FIG. **2**, etc., to operate, and a DB. The communication interface **10***b* is an interface that controls communication with other apparatuses and is a network interface card, for example.

The CPU **10***d* reads a program that performs the same processes as those of the processors illustrated in FIG. **2**, etc., from the HDD **10***a* or the like and expands the program in the memory **10***c*, and thereby allows processes that perform the functions described in FIG. **2**, etc., to operate.

Namely, the processes perform the same functions as those of the processors included in the primary master node **10**. Specifically, the CPU **10***d* reads a program having the same functions as the DB updating unit **14**, the intra-center notifying unit **15**, the inserting unit **16**, the center-to-center notifying unit **17**, etc., from the HDD **10***a* or the like. Then, the CPU **10***d* performs processes that perform the same processes as those of the DB updating unit **14**, the intra-center notifying unit **15**, the inserting unit **16**, and the center-to-center notifying unit **17**.

As such, the primary master node **10** operates as an information processing apparatus that performs a redundancy method by reading and executing a program. In addition, the primary master node **10** can also implement the same functions as those in the above-described embodiments, by reading the above-described program from a recording medium by a medium reading apparatus and executing the read program. Note that a program referred to in other embodiments is not limited to being executed by the primary master node **10**. For example, when another computer or server executes a program or when the computer and the server execute a program in cooperation with each other, too, the present invention can be applied in the same manner.

In one aspect, an increase in data lost in reflection of update information can be suppressed.

All examples and conditional language recited herein are intended for pedagogical purposes of aiding the reader in understanding the invention and the concepts contributed by the inventor to further the art, and are not to be construed as limitations to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A redundant system comprising:

a primary system including:
- a first node; and
- a second node that backs up the first node; and

a secondary system including:
- a third node; and
- a fourth node that backs up the third node, wherein

the first node in the primary system includes:
- a processor that executes a first process including transmitting data update information to the second node and the third node, the data update information being generated in response to a data update in the first node, and

the fourth node in the secondary system includes:
- a processor that executes a second process including:
- determining a degree of progress in transactions indicated by the data update information obtained through the second node and a degree of progress in transactions indicated by the data update information obtained through the third node,

specifying the data update information indicating a further progressed transaction, and

reflecting the specified data update information to stored data of the fourth node, wherein

the first process includes inserting, when transmitting the data update information to the second node and the third node, one or a plurality of pieces of delimiter information into both of transmit data, and

the determining includes determining each of the degrees of progress in transactions based on a number of transactions indicated by the data update information later than a last piece of delimiter information included in the obtained data update information.

2. The redundant system according to claim **1**, wherein the one or the plurality of pieces of delimiter information includes order information indicating a transmission order, and, wherein

the determining includes determining the degrees of progress in transactions when first order information indicated by a last piece of delimiter information included in the data update information obtained from the second node and second order information indicated by a last piece of delimiter information included in the data update information obtained through the third node indicate a same order, and

the reflecting includes reflecting the data update information including further progressed update information among the data update information obtained from the second node and the data update information obtained through the third node to the stored data when the first order information and the second order information are different.

3. The redundant system according to claim **1**, wherein

in response to a stop of the first node, the specifying includes specifying the data update information indicating the further progressed transaction, and

the reflecting includes reflecting the specified data update information in the stored data of the fourth node, and, wherein

the second process further includes performing control to switch the fourth node to a primary node in the secondary system, when the reflection of the update information indicating the further progressed transaction completes.

4. A method for a redundant system, the method comprising:

transmitting, by a first node of a primary system, data update information to a second node that backs up the first node and a third node of a secondary system, the data update information being generated in response to a data update in the first node, and

determining, by a fourth node that backs up the third node, a degree of progress in transactions indicated by the data update information obtained through the second node and a degree of progress in transactions indicated by the data update information obtained through the third node,

specifying, by the fourth node, data update information indicating a further progressed transaction, and

reflecting, by the fourth node, the specified data update information to stored data of the fourth node, wherein

the transmitting includes inserting, when transmitting the data update information to the second node and the third node, one or a plurality of pieces of delimiter information into both of transmit data, and

the determining includes determining each of the degrees of progress in transactions based on a number of transactions indicated by the data update information later than a last piece of delimiter information included in the obtained data update information.

5. A non-transitory computer-readable recording medium having stored therein a program that causes a computer to execute a process comprising:

determining a degree of progress in transactions indicated by data update information obtained through a second node that backs up a first node of a primary system and a degree of progress in transactions indicated by data update information obtained through the third node of a secondary system,

specifying the data update information indicating a further progressed transaction, and

reflecting the specified data update information in stored data of the computer in corresponding to a fourth node that backs up the third node, wherein

the process includes inserting, when transmitting the data update information to the second node and the third node, one or a plurality of pieces of delimiter information into both of transmit data, and

the determining includes determining each of the degrees of progress in transactions based on a number of transactions indicated by the data update information later than a last piece of delimiter information included in the obtained data update information.

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